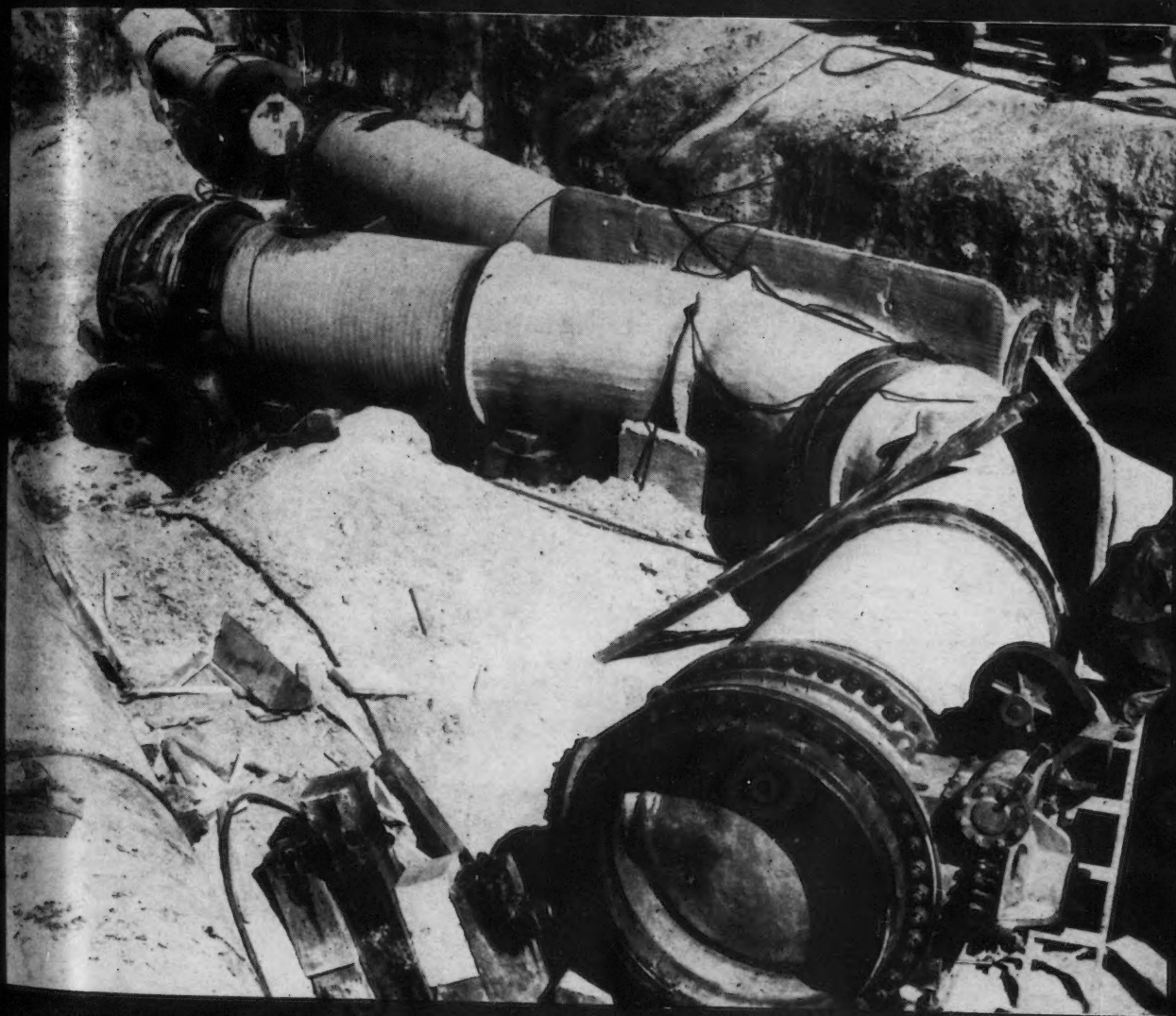


Corrosion

Official Publication
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



JUNE 1952

No. 6

CORROSION

affects every industry

BILLIONS OF DOLLARS ARE LOST ANNUALLY

And your plant is not immune. Corrosion may attack in many ways...

1 Your Hard-to-Get Equipment

... may be ruined by constant attack of acids, alkalis, fumes, chemicals, moisture, gases and weathering.

2 Your Valuable Products

... are subject to contamination and loss whenever they are in contact with corroded surfaces.

3 Expensive Shutdowns

... and loss of production with costly man-hours for repairs may be incurred unnecessarily.

4 Your Profits

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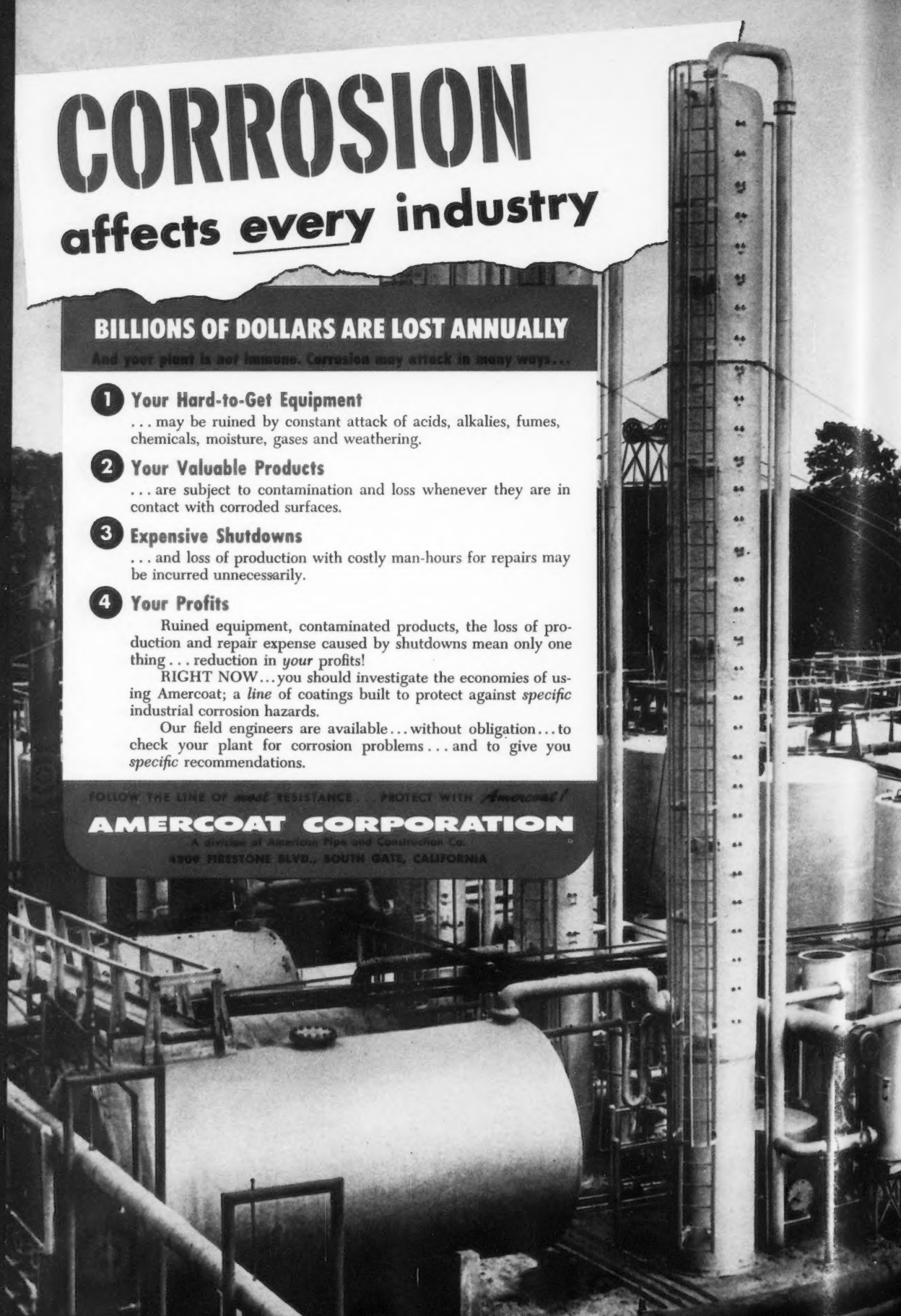
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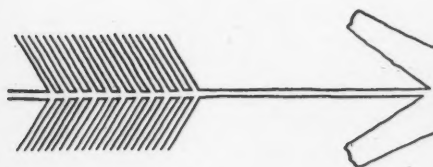
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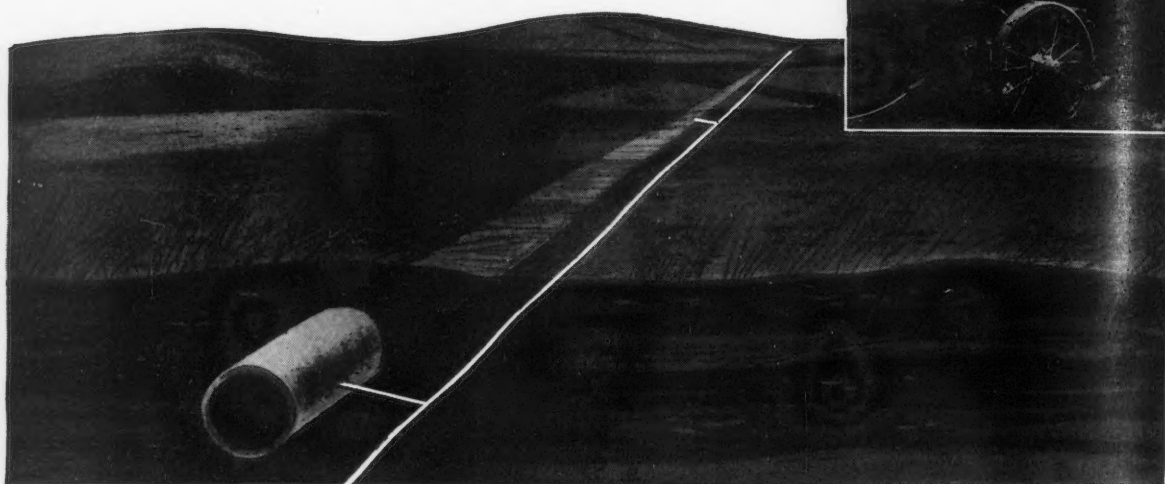
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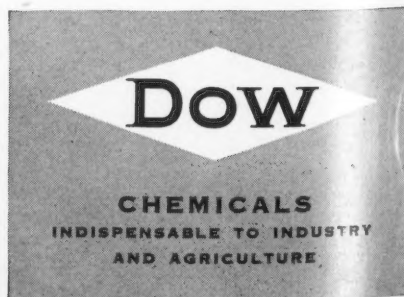
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THIS MONTH'S COVER—These are cross connections being installed in the Mokelumne Aqueducts at Walnut Creek, Cal. Solution of galvanic corrosion problems encountered in these pipes serving the east bay cities of the San Francisco Bay area with water is given in a technical paper in this issue beginning on Page 212.



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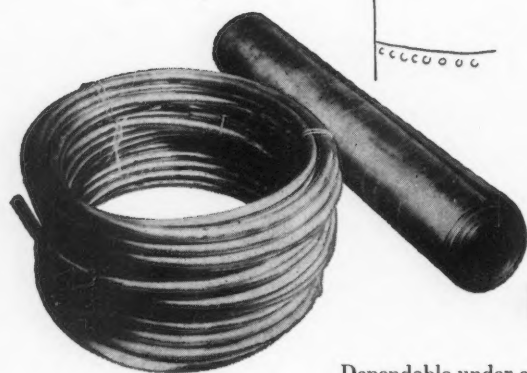
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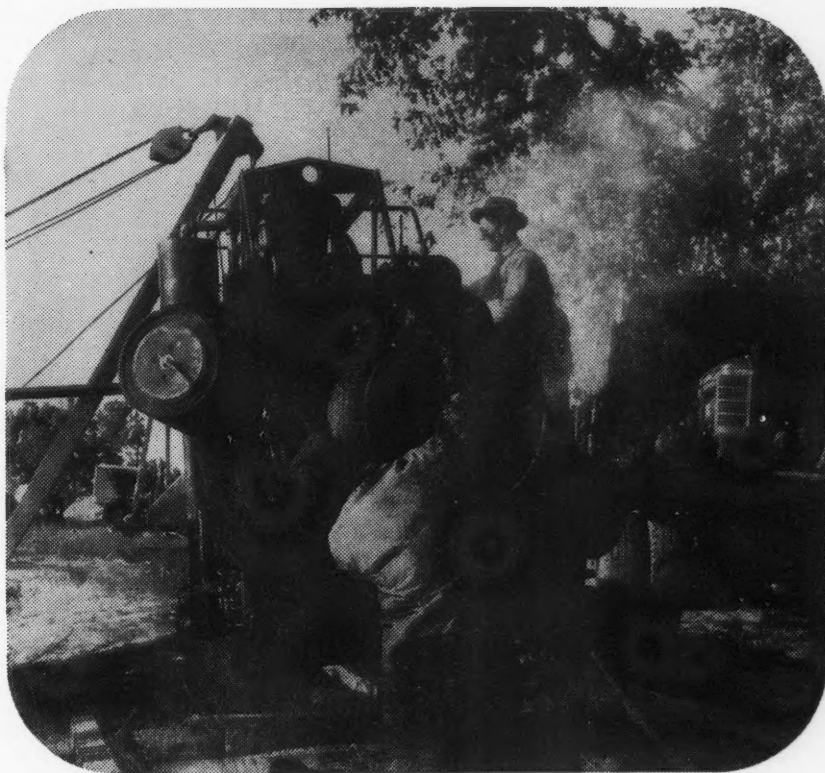
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TP-16E Corrosion and Protection of Pipe-Type
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Electric Co., 2301 Market St., Philadelphia
3, Pa.

TP-16F Nonmetallic Sheath Coatings. Geo. H. Hunt,
Chairman, Simplex Wire & Cable Co., 79
Sidney St., Cambridge 39, Mass.

TECHNICAL PRACTICES COMMITTEES' DIRECTORY

(Continued from Page viii)

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APPROVED MANUSCRIPTS

Aluminum Alloys for Offshore Pipelines by E. T.
Wanderer and D. O. Sprows. Galveston No.
26.

Corrosion Resisting Characteristics of Iron
Modified 90:10 Cupro Nickel Alloy by W. C.
Stewart and F. L. LaQue. Galveston No. 33.
Some Corrosion Experiences With Aluminum
Crude Oil Lines by Almont Ellis. Corpus
Christi Regional Meeting, 1951.

A Hydrogen Evolution Method for Evaluation of
Corrosion Inhibitors for Oil Wells by Willard
R. Scott and Gilson H. Rohrback.

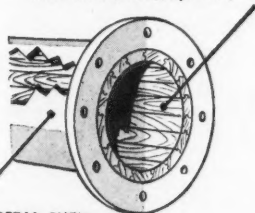
Vigilance Underground. A Summary of Progress
on Preventing Electrochemical Corrosion on
Buried Pipe Lines by Bryan Patterson, Hill,
Hubbell & Co., Cleveland, Ohio.

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MICHIGAN PIPE COMPANY

Bay City • Michigan

CORROSION—June, 1952

Left Tank: 10-mil thickness of protective coating
after 3 years' service.

Right Tank: 3-mil thickness of same system failing
after 2 years.



For Your Maintenance Painting:

more Coats, or more Thickness?

Practical Pennsalt System Proved in Plant Usage with PENNPAINTS

The above photo of acid storage tanks clearly illustrates the difference between good and poor paint maintenance programs. Taken at Pennsalt's Wyandotte, Mich., plant, it shows part of the results of a 3-year study of painting programs. The method was developed by actual painting crews and plant engineers . . . is not just a theoretical laboratory test.

Now Pennsalt can offer you a painting system which your own maintenance painting crew can use . . . a system which produces greater *thickness* of coats, with fewer *number* of coats. This system—using Pennsalt's own Pennpaints—was tested in actual plant use, against 62 other common paint systems.

Thicker coats, and fewer of them, not only proved more efficient, but also more economical in the long run. And when you realize that industry pays an annual maintenance bill of \$2 billion *for painting alone*, this new Pennsalt program begins to look pretty important, doesn't it?

Of course, the subject is too complex to be discussed in detail here. But a word from you will bring complete data to you on the run. Write: Corrosion Engineering Products Department, Pennsylvania Salt Manufacturing Co., Philadelphia 7, Pa.



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Progressive Chemistry for over a Century

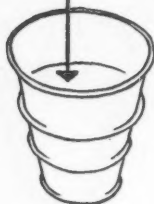


News about COATINGS for METALS

Metallic Organic Decorative Protective

"101" Corrosion Problems

A better lining FOR DRUMS THAT TAKE A BEATING



Lining drums is always a good idea, but even more so today, when you've steel shortages to contend with. Perhaps you've heard about how Unichrome Drum Linings are able to prevent corrosion

of container and subsequent contamination of contents for many products.

But you may not have realized how wide a range of applications these linings really have—or how long they last. Such materials as synthetic wetting agents and detergents, alcohols, vinyl latex solutions, bleaches, solvents, acids, foods and many other products are successfully resisted by one of the various types of Unichrome Drum Linings. These save drums from the punishment of long contact with the corrosives and often permit reuse without relining.

Do you have a tough packaging problem? Write us about it.

Plastisol-clad Metals

Last in Corrosive Service

Available metals can frequently be used where service conditions are extremely corrosive—if they're protected with a Unichrome Plastisol or Organosol Compound.

These are flexible coatings which resist chipping and abrasion . . . and when applied by dipping or spraying and baked at 350° F, build film thickness up to 3/16" with a single application. This build-up multiplies the protective qualities of these vinyl-base compounds.



Ucilon Protective Coating Systems maintain equipment against attack of many strong chemicals and corrosives*

Warnings are up. With equipment getting harder to replace, corrosion losses have to be cut. And they can be, through the aid of Ucilon Protective Coatings.

Unlike ordinary paints, systems based on Ucilon Coatings give enduring protection against a "hundred and one", strong chemicals or corrosives. By using the recommended system for your problem you get protection that lasts longer. Not only do you help keep vital equipment in continued service, but also reduce the labor and down-time expense of frequent painting.

Chemical Properties of Ucilon

Ucilon Coatings contain corrosion fighting ingredients noted for their chemical resistance—including vinyl, phenolic, chlorinated rubber or fish oil base materials. For increased durability and adhesion, wash primers, primers, and intercoats are available where individual applications require them. Used in systems of coatings, the various Ucilon Coatings form a film highly resistant to strong acids, alkalis, alcohols, salt solu-

tions, moisture, oils and other paint-destroying corrosives.

Typical Performance Records

Ucilon Coatings used to line brine storage tanks in an alkali plant were in good condition after 5 years' remarkable service!

Concrete and steel storage tanks for gasoline and fuel oils are being lined with a Ucilon Coating System devised for these corrosives. It was found best of all linings tested—giving excellent resistance to cracking and no contamination by leaching.

A paper and pulp mill, using a Ucilon Coating System on wet ends of Fourdrinier machines, term it the *only material ever found to withstand the unusually severe, corrosive conditions.*

* * *

Send today for the CONDENSED UCILON BULLETIN that lists the 101 common corrosion problems and the Ucilon Coating Systems that offer you long lasting protection against each at lowest cost.

*Trade Mark

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WHAT KONTOL DOES

BOTH

WHAT KONTOL DOESN'T

A cheap corrosion preventive is not necessarily economical. Safety in handling, ease of application and the avoidance of treating difficulties or formation-plugging precipitates are all values to be carefully considered in selecting a corrosion inhibitor.

KONTOL DOES

Prevent corrosion—by forming a tightly adsorbed protective film on the metal surfaces of production equipment.

Prevent production interruptions—by eliminating the frequent break-downs and equipment failures caused by corrosion damage.

Save time—by being easy to use, by not complicating production procedures, by helping to keep the wells on production.

are important

KONTOL DOES NOT

Require elaborate application procedures—it can be pumped, lubricated or dumped into the well, or applied in solid stick form.

Require special safety measures—it is safe and convenient to use. No gloves, goggles, masks, or extraordinary precautions are required.

Complicate ordinary production procedures—it does not render emulsified crudes more difficult to demulsify. It does not deposit well-plugging precipitates.



TRETOLITE COMPANY

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CORROSION INHIBITING • DEHYDRATING • DESALTING
WATER DE-OILING • SCALE PREVENTING • PARAFFIN REMOVING

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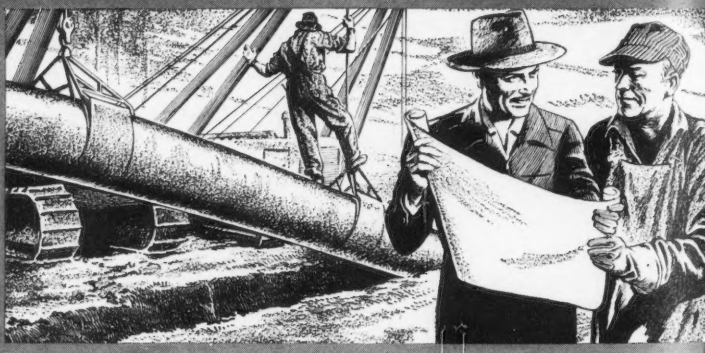
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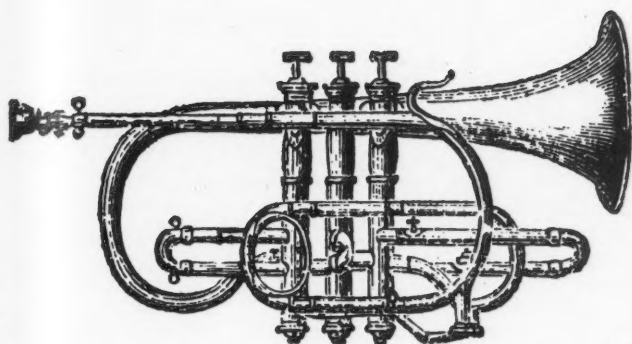


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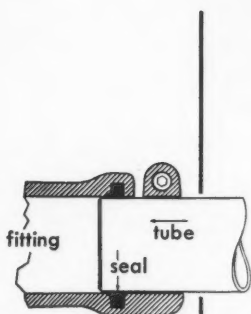
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without threading or welding

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THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
- (d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- (e) To promote standardization of terminology, techniques, equipment and design in corrosion control.
- (f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.



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The Editorial Review Committee

By **GEORGE DIEHLMAN**, Chairman
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BECAUSE of their far-reaching significance, all scientific or technical papers offered for publication in the official NACE magazine "Corrosion" are carefully reviewed by the Editorial Review Committee—a subcommittee of the Publications Committee.

At present, the committee consists of five members including the chairman. Another member will be included to reduce the work of each present member and also to facilitate the processing of papers. The chairman is selected from the committee membership on a rotating basis and holds his office for one year. At the conclusion of his term, he must retire from the committee. Thus one new member is added to the committee each year. The Editorial Review Committee membership is so constituted that a diversified field of corrosion interests is represented. Committee members usually supplement their own review efforts by consulting persons who have specialized knowledge and experience on the subject matter referred to in the papers. Where considered desirable, authors of papers are given the benefit of suggested modifications, adjustments or inclusions.

The authors of papers, as well as the readers of "Corrosion," mutually benefit by the review procedure. When a paper has been accepted for publication, the authors have the added satisfaction of knowing the information contained has been adjudged a well presented and worthwhile contribution to the fund of knowledge on corrosion or its mitigation. Readers can feel secure in knowing that established NACE standards for papers are being maintained through the review process.

The Editorial Review Committee, or any component of an association as large as the NACE, is of necessity dependent on others within the organization in order that its duties may be satisfactorily discharged. Dr. Ivy M. Parker and Norman Hammer, the editor and managing editor respectively of "Corrosion," are among the many who fully cooperate in our efforts and whose advice and guidance are invaluable.

To maintain the prestige of "Corrosion" as the foremost source of published scientific and technical information on corrosion and its mitigation, requires a steady supply of constructive papers to the Editorial Review Committee. The committee welcomes and is always glad to review voluntary papers on corrosion matters when they are offered through the office of the Executive Secretary of NACE. Papers presented at the various symposia during the annual conference are one source of supply to the review committee. However, other sources of papers are both desirable and necessary in order to accomplish our aim. There are a large number of worthwhile papers on corrosion subjects presented before sectional and regional NACE groups during the course of each year. A large number of these papers are never offered for subsequent publication in "Corrosion." Our sectional and regional officers can be most helpful in this endeavor if they will ask the authors who address their respective groups to provide a finished copy of the presented paper along with authorization to offer it for publication. All authors should be furnished a copy of the "Guide for Preparation and Presentation of Papers" which will be most valuable to them in writing a paper for "Corrosion." Another means of securing papers on corrosion subjects would be those papers which have been published or presented outside official NACE circles, provided they represent subjects of wide interest and would not normally come to the attention of the majority of readers of "Corrosion."

Through cooperative effort, the Editorial Review Committee will continue to strive for papers of top quality for publication in "Corrosion." Ideas and suggestions are always welcome.

Current members of the committee, in addition to the chairman, are F. N. Alquist, T. P. May, J. W. Ryznar and A. W. Tracy.

By-Laws of the Inter-Society Corrosion Committee

National Association of Corrosion Engineers

As Approved by Letter Ballot of March 3, 1950

I. Objectives and Scope

1. To promote cooperation among technical societies working in the field of corrosion.
2. To act in an advisory capacity to the various technical societies interested in corrosion in an effort to promote progress of all and avoid excessive duplication of effort.
3. To recommend in which society a proposed new activity might best be carried out without, however, attempting to define or limit the field of activity of any society.
4. To stimulate the publication of corrosion data, disseminate information on corrosion, and promote recording of experience by engineers and scientists in the field and in the laboratory.
5. To provide information pertaining to the scheduling of conferences and conventions in this field.
6. To promote the standardization of definitions and terminology in the field of corrosion.

II. Membership

1. Any technical society working actively in corrosion is entitled to appoint two delegate members to this committee by notice to the Chairman of the committee and may withdraw from participation in the affairs of the committee by giving similar notice at any time. Appointed delegates need not be personal members of the N.A.C.E., but it is desirable that they should be. The term of office of a delegate member shall be determined by the society he represents, but preferably should be at least two, and not more than six years.
2. Each governmental agency formerly represented on the American Coordinating Committee on Corrosion may appoint one delegate to this committee. Any other major governmental agency of the United States or Canada actively engaged in the corrosion field in cooperation with industry and with program and results made available to the public may apply for representation on the committee by one delegate.
3. There shall be no other members.

III. Officers

1. The committee shall have a Chairman, Vice-Chairman and Secretary. The Chairman and Vice-Chairman shall be elected by majority letter ballot of all delegates in the even number years for a term of two years. The Chairman and Vice-Chairman shall be from different technical societies. No one society shall be represented by a Chairman for more than one term in any six-year period.
2. The Chairman shall appoint a nominating committee of any three delegates not later than December 1st of each odd number year. This committee shall report its slate to the Chairman by the following January 15th so that an election can be held by letter ballot prior to the annual meeting of the N.A.C.E. and so that the new officers can be inducted at that time or not later than April 15th. The incoming officers will take over their duties immediately following the meeting at which they are inducted.
3. The Executive Secretary of the N.A.C.E. shall be the Secretary of the Committee, but he shall not be considered as one of the delegates from the N.A.C.E. If the Secretary should be unable to attend a meeting, one of the delegates shall be appointed by the Chairman to serve as Acting Secretary.

IV. Meetings

1. The committee shall meet at least once each year at the call of the Chairman. Preferably this should be at the time and place of the annual meeting of the N.A.C.E. The meeting held at such time shall be

considered the annual meeting of the committee. Otherwise the meeting held prior to April 15th at which new officers are inducted will be the annual meeting.

V. Voting

1. Each delegate member shall have one vote.
2. Except as provided in Items 3 and 4a of this section, a majority affirmative vote of those voting at regular meetings or by letter ballot shall be required to approve any motion or action. Fifty percent of the total number of delegate members shall constitute a quorum at regular meetings.
3. These by-laws shall become effective only upon a 75 percent or more affirmative vote of the voting delegate members representing technical societies on a letter ballot circulated to all of the technical societies represented. Changes in these by-laws shall be effected by the same procedure.
- 4a. Except in the matter of changing by-laws, or where otherwise specifically stated in a motion, the vote of a delegate shall be considered as his personal vote and not the vote of the society he represents. No action taken by ordinary motion shall be considered as binding upon the various technical societies represented on this committee.
- 4b. Where it is desired that a vote represent the views of the various technical societies represented—as in the case of changes in these by-laws—a special vote shall be taken by letter ballot, with the delegate, or delegates, from each society casting a single ballot based on specific instructions to be secured from the society represented.

VI. Sub-Committees

1. Each Chairman shall appoint the following standing sub-committees:
 - a. Membership sub-committee to consist of any 5 delegates.
 - b. Sub-committee on standard definitions and terminology.
 - c. Sub-committee on relations with foreign technical organizations.
2. The Committee shall have the power to organize additional sub-committees to carry out specific tasks that cannot be handled as well by existing committees of the N.A.C.E. or other societies.
3. Members of the standing sub-committees with the exception to be noted must be delegate members of the Inter-Society Corrosion Committee. In the case of the sub-committee on Standard Definitions and Terminology, members need not be delegate members of the Inter-Society Corrosion Committee or of the N.A.C.E. and may be permitted to attend meetings of the committee as observers without voting privileges.
4. Sub-committees shall be responsible to the committee who will receive and act upon reports submitted to them.

VII. Dues

1. There shall be no dues for membership in this committee and no contributions will be required from the participating societies or organizations.

VIII. Amending By-Laws

Proposed amendments to these by-laws shall be submitted in writing to the Chairman with a sufficient number of copies for distribution by him to all delegates at least 30 days in advance of the annual meeting. Only after approval by a majority of those voting at the annual meeting shall the proposed amendments with any modifications approved at the meeting in the same manner be submitted for final approval by letter ballot as provided in Section V of these by-laws.

Gasoline Resistant Tank Coatings*

By W. W. CRANMER

Foreword

THIS PAPER was prepared for the Marine Industry Symposium of the spring 1952 meeting of the National Association of Corrosion Engineers. To a large extent, the paper reports work sponsored by the Bureau of Ships, Department of the Navy, over the period 1943 to 1951. The information has been developed from many sources, including government and private laboratories, and the coatings, shipping and petroleum industries. Specific acknowledgment is not given in many instances, since the information has been combined and summarized. However, the author would be extremely remiss if a general acknowledgment were not made, with an expression of appreciation to the many who have cooperated with the Department of the Navy in this work.

Review of the Problem

The transportation and storage of petroleum products involves many familiar corrosion problems. An especially troublesome problem arises when refined products such as gasoline are transported in bulk in mild steel tanks which are an integral part of the structure of a ship. Figure 1 is representative of such tanks. The occurrence of platforms, strength members and the corrugations of the sides complicates the structure to the extent that the actual internal metal surface is about twice the area that would be calculated from outside dimensions.

If such tanks always operated completely full of gasoline, no serious corrosion would occur. However, after being emptied of gasoline, it is usual to ballast the tank with sea water. It is also usual to use hot sea water jets intermittently to assist in removing inflammable vapors and to dislodge scale from the tank surfaces. It is also obvious that water may condense on tank surfaces when the tanks are only partly full. Finally, fresh or brackish water of indeterminate purity may be used in place of sea water for ballast, and steam is sometimes used for removing inflammable vapors.

Table I presents some data on measured rates of corrosion.¹ The source of this data states that this "is a summary of results from a number of corrosion tests in tankers of several oil companies. These data are average values and are very close to observations made in a tanker after service for a number of years. The rates were obtained by exposing four-inch square specimens of 1/4-inch plate on a conventional specimen holder with the specimens themselves in a vertical position. . . . The majority of the tests were of one to two years' duration. . . . In each test, one set of specimens was mounted near the bottom so that it was continuously submerged. A second set was

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Abstract

Rapid corrosion of steel occurs in cargo tanks of Navy tankers when successive cargoes of gasoline are carried. The corrosion results from salt water ballast, hot salt water jets used for gas-freezing and moisture, in conjunction with the gasoline.

The nature of the structures is such that only air drying paints are practicable. Search for such coatings began about 1943. Certain coatings were applied to several ships about 1947. Service under operating conditions resulted in the selection of a vinylidene chloride-acrylonitrile copolymer as most promising. General use of this coating on certain tanks of submarines began in 1948. Active use on tankers began in 1951. Trial on tank cars was started in 1950. Two hundred cars are now in use transporting aviation gasoline and jet fuel.

A large number of materials, including many proprietary coating systems, have been tested. Laboratory tests are still continuing. As warranted, service trials are contemplated on additional materials, some of which are sufficiently promising to warrant direct comparison to the present standard under operating conditions.

A discussion of the problem of coating underground concrete gasoline storage tanks is included, using data furnished by the Naval Research Laboratory.

The paper will also include a discussion of surface preparation, ventilation, safety precautions and costs. Likewise, a discussion of methods other than coatings which have been investigated to reduce this corrosion problem will be included.

mounted as near the top of the tank as possible so as to expose the set to air, vapors and splashing. . . . Pitting was not reported in this table because the retirement of tankers is usually determined by the average corrosion rate rather than by pitting. Nevertheless, severe pitting has been reported in the bottoms of tanks carrying high sulfur crudes."

It has been found that laboratory immersion tests

TABLE I—Corrosion Rates of Mild Steel in Tankers

Exposure	Average Penetration, ipy	
	Top	Bottom
Gasoline—no ballast	0.0107	0.0098
Gasoline—sea water ballast	0.0087	0.0064
Gasoline—brackish ballast	0.0109	0.0032
Crude oil—brackish ballast	0.0039	0.0013
Sea water		0.0056
Marine atmosphere		0.010

*A paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952.

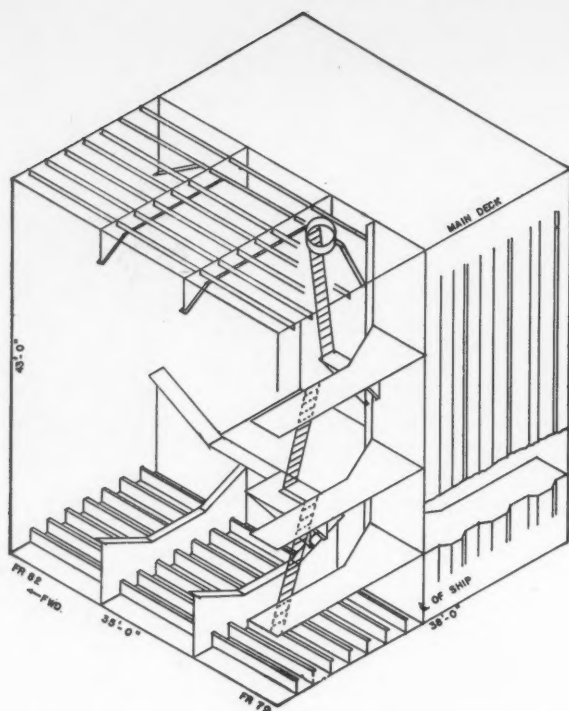


Figure 1—Pictorial isometric sketch, main gasoline cargo tank.

do not correlate with observations of actual corrosion in this instance. For example, laboratory tests show a rate of 0.001 ipy for gasoline alone, 0.004-0.005 ipy for salt water alone, with a 25 to 100 percent acceleration when mild steel was exposed to salt water blanketed with gasoline. These tests were carried out in beakers containing both salt water and gasoline and do not represent alternate immersion. The same source estimates the corrosion rate of mild steel alternately immersed in gasoline and salt water to be 0.015 to 0.020 ipy, or three to four times the normal rate in salt water alone.

Actual measurements of corrosion losses² in a tanker after five years of gasoline service were found to average about 0.16 inches, or roughly, one-third the original plate thickness. This is based on wastage from two sides, and would calculate to a penetration of about 0.016 ipy.

A practical approach is to find out how long a tank will last in this service before structural replacement is needed. While no definite answer has been obtained, most answers are in the range of either 5-7 years or of 10-12 years. The answer must depend somewhat on the number of cargoes carried in a given time. It is interesting to note that the prewar tanker carried 130 cargoes in 7 to 8 years, whereas more modern tankers carry the same number of cargoes in 5 to 6 years.

It is generally agreed that this corrosion is caused by salt water and accelerated by gasoline. It has been suggested³ that this is due to the fact that oxygen is six times as soluble in gasoline as in sea water. Therefore, as sea water enters the tanks a tremendous

reservoir of oxygen is available from the gasoline to cause corrosion wherever water is in contact with the steel.

Protective Coatings

About 1943, this laboratory was requested to investigate the problem of finding a paint-like coating for protecting gasoline cargo tanks. An immediate decision was to eliminate heat-cured finishes, since their proper application and curing appeared impracticable. Initial tests involved alternate exposure to gasoline of high aromatic content and sea water. This cycle was later modified to include immersion in hot sea water and exposure to a jet of hot sea water under pressure, to simulate commercial gas-freeing and cleaning practices. Early tests eliminated conventional petroleum-resistant materials such as shellac, nitrocellulose and alcohol soluble phenolic resins and indicated that the most promising materials were high polymers, including vinyl-, polysulphide- and acrylonitrile-types and combinations of these types.

It is important to note that a combination of good hydrocarbon and sea water resistance is not sufficient, since some hot cleaning operation is sooner or later encountered by such coatings. Figures 2, 3, and 4 illustrate the importance of the temperature of the hot sea water phase of the test cycle. Figure 2 illustrates a coating that gave good performance at 130 degrees, poor performance at 155 degrees and 175 degrees F. Figure 3 illustrates another coating that gave good performance at 130 degrees and 155 degrees but poor performance at 175 degrees F. Figure 4 illustrates a coating showing good performance at all three temperatures. These tests at various temperatures were undertaken after an early series of tests had indicated that a temperature of 185 degrees F. was harmful to every coating tried. (Later service trials have also indicated that "hot" operations contribute materially to coating failure.)

In 1946, laboratory screening of coating materials had progressed to the point where it was possible to recommend trial of four materials under actual service conditions. One of these materials, consisting of a solution in methyl-ethyl-ketone of a vinylidene chloride/acrylonitrile copolymer, was without any evidence of failure after being in laboratory test for 48 weeks. A second material, representing a proprietary formulation suspected to utilize vinyl resins was also without failure after 48 weeks. A third material, representing a proprietary formulation of mixed polysulfide and vinyl resins had been in test 38 weeks and showed no failure except for very slight blistering. A fourth coating system, utilizing various coats of a butadiene-acrylonitrile copolymer with a sandwich coat of a "Nylon" type polyamide resin solution was also without failure after 30 weeks in test. These were the only coatings which appeared promising after about 2½ years of testing.

Service Trials

In the latter part of 1947, one centerline main cargo tank on a Navy tanker was selected for a trial of promising coatings.

Figure 5 shows the corroded condition of the tank structure before starting coating operations. The first operation was to clean by sand blasting. (In this instance, wet sand blasting using dichromate as inhibitor during blasting and washing down with dilute phosphoric acid was used. This procedure is not recommended, since later trials have shown dry sand blasting to be better.) The entire tank surface was coated, assigning different areas to each of the three coatings tried. For brevity, these coatings are identified as follows:

- a. Polysulfide-type (a proprietary coating understood to use a combination of vinyl and polysulfide resins).
- b. Vinyl-type (a proprietary coating understood to use vinyl resins).
- c. Saran-type (an approximately 20 percent solution of a vinylidene chloride/acrylonitrile copolymer, 1000 centipoise type, in methyl-ethyl-ketone).

Figure 6 shows an area of the tank after coating with the Polysulfide-type material. Figure 7 shows the same area after being in service for 19 months.

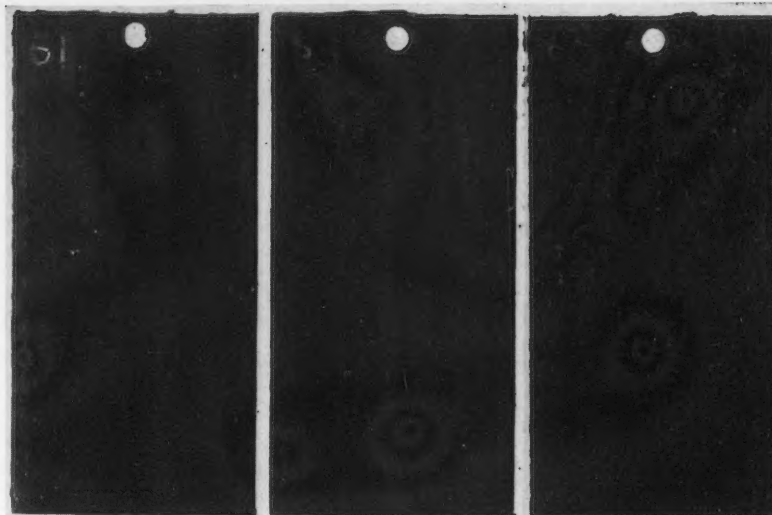
The polysulfide-type material was applied at an average thickness of 13.1 mils (52 measurements taken; minimum reading, 8 mils; maximum reading, 19 mils). This involved an initial brush coat, followed by three spray coats. The vinyl-type material was applied at an average thickness of 7.4 mils (53 measurements taken; minimum reading, 5 mils; maximum reading, 12 mils). This involved an initial brush coat, followed by five spray coats. The Saran-type material was applied at an average thickness of 7.1 mils (35 measurements taken; minimum reading, 5 mils; maximum reading, 10 mils). This required five brush coats.

Figure 8 shows an area of the tank after coating with the vinyl-type material. Figure 9 shows the same area after 19 months' service. Figure 10 shows another area of the same coating after 19 months' service and a blistering type of failure later found to be typical of this coating.

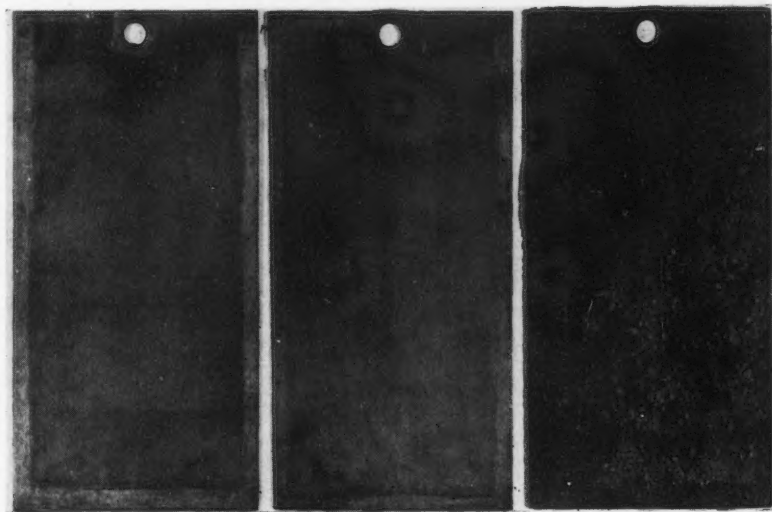
Figures 11 and 12 show an area after coating with the Saran-type material and after 19 months' service.

This service trial ended after 43 months because of general rearrangement of cargo spaces on this ship. During the first 34 months of this period it was possible to obtain an accurate log of operations, as follows:

- a. 397 days carrying motor or aviation gasoline.
- b. 18 days carrying sea water ballast.



130 degrees F 155 degrees F 175 degrees F
Figure 2—Effect of temperature failure at 155 degrees F and 175 degrees F.



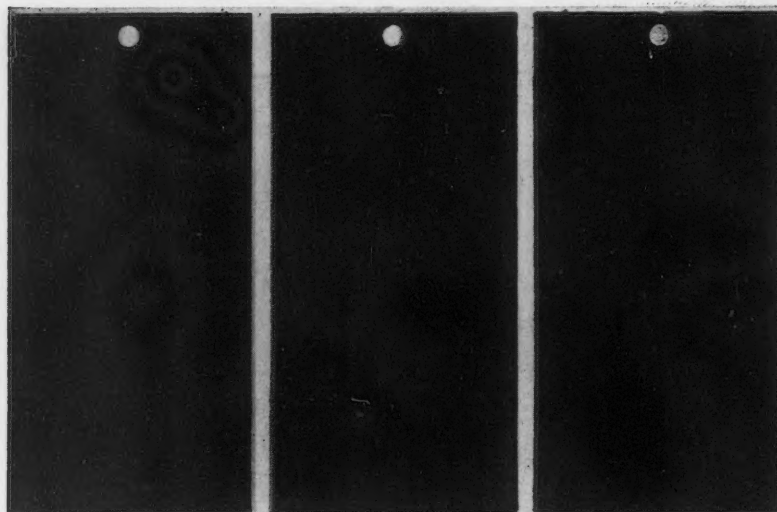
130 degrees F 155 degrees F 175 degrees F
Figure 3—Effect of temperature failure at 175 degrees F.

- c. 16 gas-freeing operations (hot sea water jets at about 175 degrees F, total time about 100 hours).
- d. Otherwise empty, but exposed to salt air, sea water on tank bottom and condensation.

During the last nine months of service, no accurate information was available, except that the tank had been gas-freed at least once.

During the service period about one barrel of scale and sludge had accumulated in the tank. It was estimated that about 100 barrels of sludge and scale had been removed from an adjacent uncoated tank in similar use. There was no evidence of structural damage by corrosion in the coated tank. No clogging of pipes, pumps or adulteration of cargo by the coatings was experienced.

The best coating was the Saran-type. Typical failure was by moderate pinpoint rusting, with no evi-



130 degrees F 155 degrees F 175 degrees F
Figure 4—Effect of Temperature satisfactory at 175 degrees F.



Figure 5—Typical scaly corrosion in gasoline cargo tank.

dence of deep rusting or pitting. Touch-up was accomplished on a part of the Saran coated area and was found to be successful. At the conclusion of the service test, areas touched-up had experienced 24 months' service and were in perfect condition.

The vinyl-type coating was found to be unsatisfactory. Despite some limited areas which showed early blistering, this coating was generally excellent up to 19 months' service. However, at some period between an inspection made after 19 months and a later inspection after 34 months, this coating failed extensively by blistering with subsequent rupture of blisters, and peeling. Touch-up was found to be unsatisfactory because blistering re-occurred in areas where initial blisters had been removed and recoated.

The polysulfide-type coating was least satisfactory

of the three tried. Typical failures, beginning after less than 13 months' service involved blistering and peeling with eventual rust creepage under the coating.

It will be noted that the butadiene-acrylonitrile copolymer system with a polyamide ("Nylon"-type) sandwich coat was not included in this service test. This omission was necessary because the specific primer originally tested was not available when the service test was started. Considering the complexity of this system comparative to the Saran-type coating, it is probable that no further investigation of such system will be made. This, of course, does not eliminate further consideration of butadiene-acrylonitrile type materials.

Simultaneous with this service test, material taken from the identical batches used in coating the tank was applied to panels and subjected to the laboratory test upon which the original selection was based. The Saran-type material again showed satisfactory performance. However, both the vinyl- and polysulfide-type materials developed the same failures later found in the service test. No complete explanation of this discrepancy has been obtained.

A review of this service test allows the following summation:

- a. Of the coatings tested the Saran-type material is the most satisfactory air drying coating for such use.
- b. It is practical to properly prepare the metal surface and to apply the coating under actual working conditions.
- c. The Saran-type coating will protect the structure for about four years and touch-up at four-year periods will probably extend the life of the coating until other factors cause retirement of the ship.

- d. A coated tank will not require periodic descaling; pumps and similar devices will be maintained more easily; and cleaning and cargo changeover will be easier.

Since 1947, other trials of these fuel-resistant coatings have been made, as follows:

- a. Two main cargo tanks on a Navy tanker, coated with Saran-type material, applied over dry sand blasted steel. Inspection after 15 months' service showed that the coating was in excellent condition. This ship was then inactive for a period but has now been returned to the active list. An inspection report three years after the coating was applied stated that 90 percent of the coating was intact in a continuous film.
- b. One main cargo tank on a Navy tanker, coated

with polysulfide-type material applied over dry sand blasted steel. Inspection after 19 months' service revealed that an estimated 8 to 10 percent of the tank surface was rusty or showed signs of rust but that the tank structure was well preserved, especially in comparison to an uncoated tank.

- c. Four main ballast tanks of a submarine. Coatings in this instance were exposed to only Diesel fuel and sea water. One tank was coated with the Saran-type material, a second was coated with the vinyl-type material, a third with the polysulfide-type material and the fourth tank was coated with a proprietary material based on an alcohol soluble type phenolic resin. After 19 months' service, the Saran-type material showed only superficial pinpoint rusting, mainly on the lowest three feet of the tank where maximum contact with sea water is encountered. The vinyl-type material showed extensive areas of typical medium-to-large flat blisters with rusting and peeling where blisters had ruptured. The polysulfide-type material had failed by blistering, peeling and rusting. The alcohol soluble phenolic resin material had failed completely, with little or no coating remaining on the tank and rusting very prevalent.

Current Uses

The Saran-type material is currently a standard coating for Navy use where a fuel-resistant tank lining is needed. For this purpose, it is generally applied as several brush or spray coats to a thickness of about 0.008 inches. It is pigmented either with titanium dioxide to provide a white color, or with an orange toner to provide an orange color. The orange and white materials are alternated during application of successive coats. The use of pigments is mainly to provide contrast between coats and good visibility during application. Results obtained with the pigmented material in tanks are observed to be better than initial trials where unpigmented material was used. This may be due to greater experience on the part of workmen, or to better assurance that complete coverage is obtained with each coat.

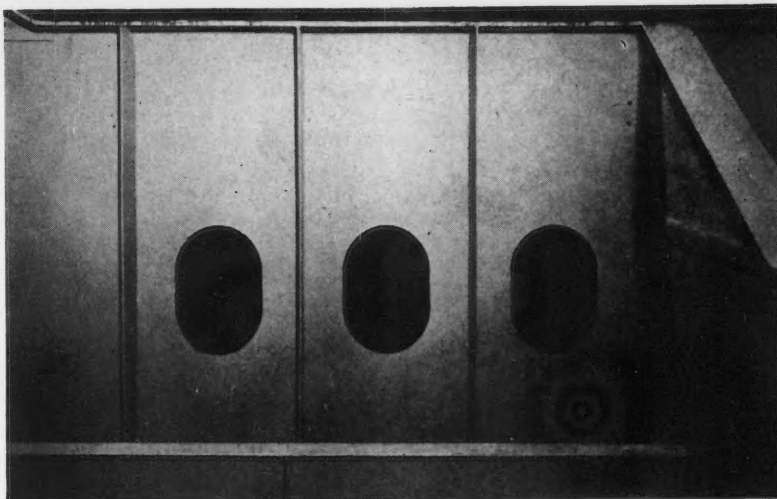


Figure 6—Area coated with polysulfide-type material.



Figure 7—Area coated with polysulfide-type material after nineteen months' service.

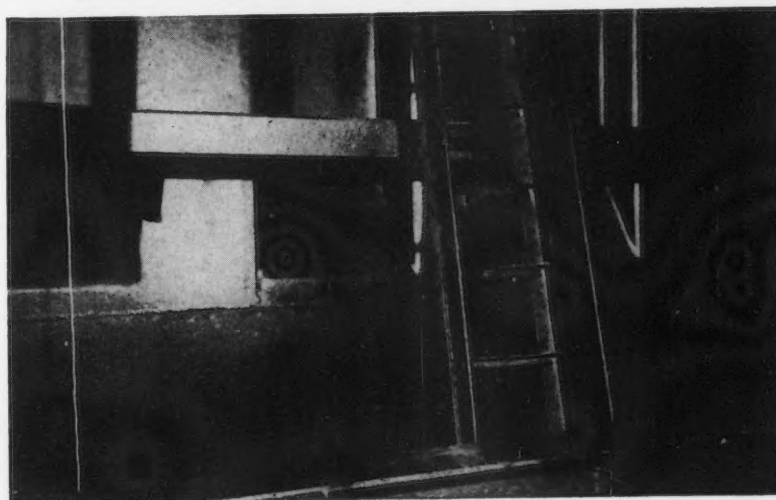


Figure 8—Area coated with vinyl-type material.



Figure 9—Area coated with vinyl-type material after nineteen months' service.

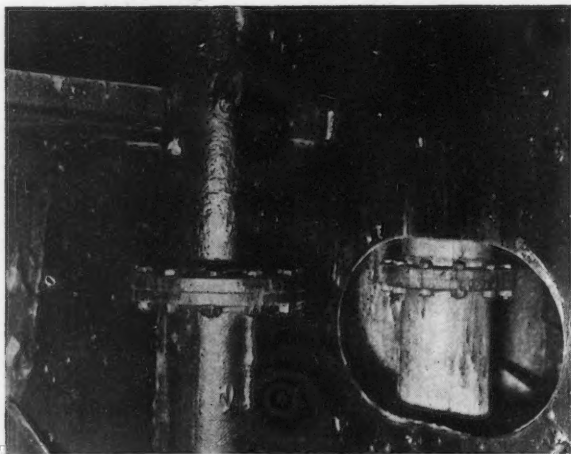


Figure 10—Area coated with vinyl-type material after nineteen months' service. Typical blistering.

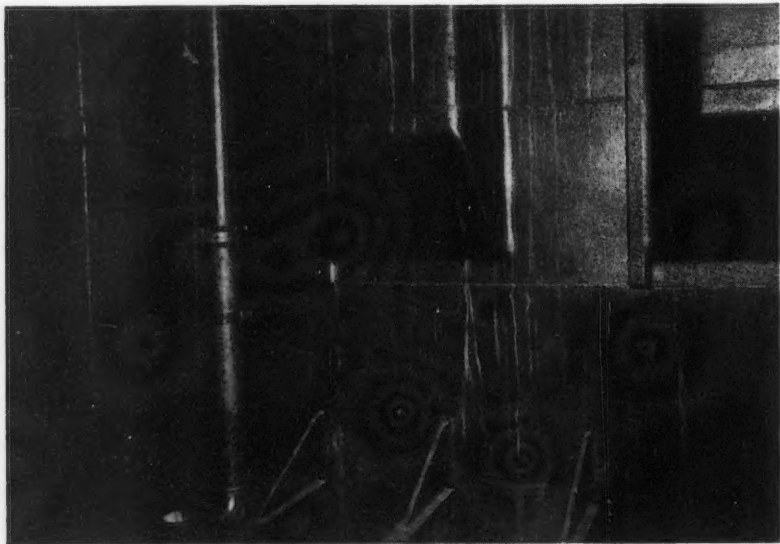


Figure 11—Area coated with Saran-type material.

However, laboratory tests show that the film is improved by pigmentation. In this connection, it is well established that the clear Saran-type material is rapidly deteriorated by sunlight. However, with proper pigmentation, very weather-resistant coatings are possible.

This coating is used on gasoline cargo tanks of tankers and certain ballast tanks of submarines. In the latter use the normal requirements are resistance to Diesel fuel and sea water but not to "hot" operations. It is usual to find that coated tanks require only minor touch-up after being in service for periods of about 30 months.

Trial on the heeling and trimming tanks of an icebreaker ship during three arctic operations (17 months' service) gave excellent results and this use being extended.

Two hundred tank cars have been coated for carrying aviation gasoline and jet fuel. Some of these have been in continuous use since July, 1950. The material is currently specified for use on tank truck refuelers used at airfields.

Application and Costs

It is obvious that the application of gasoline resistant coatings to confined, sometimes irregular and always difficultly accessible spaces, such as ships' cargo tanks, is not easy, fast or cheap. If a resin has good hydrocarbon resistance, including resistance to aromatic hydrocarbons, the resin per se will require strong solvents like ketones, esters or alcohols as solvents and usually will resist even these solvents

to the extent that only solutions of low solids content are possible. This means the coating must be built up to a proper thickness for protection and impermeability by multiple coats. At the same time, relatively large volumes of inflammable and hazardous solvents are released. In addition, poor performance can be expected unless the steel surface is thoroughly cleaned. If sandblasting is used, dust during the operation and removal of debris afterward, pose problems.

As would be expected, adequate ventilation provides the best answer to both solvent and dust hazards. An excellent reference is the paper by C. G. Munger entitled "Vinyl Coatings are Safe."⁴ Certain parts of this paper are quoted, as follows:

"The following are the few simple rules which need to be observed for the handling of vinyl or other synthetic resin coatings in enclosed areas. These rules are good practice for the installation in enclosed areas of any coating where inflammable solvents are a factor.

"1. The first and most important is ventilation. This ties directly to the lower explosive limit of solvents used in coatings, since if the solvent concentration does not reach the lower explosive limit there can be no explosion . . . The concentration of solvent in the air can be kept far below the lower explosive limit by the use of proper ventilation. This is true irrespective of the flash point, since the flash point merely represents the temperature at which the particular solvent will evaporate sufficiently rapidly to reach the lower explosive limit . . .

"In order to give a comparatively easy method of figuring possible solvent concentration in air, it is calculated that if it were completely vaporized, there would be obtained 25 cubic feet of solvent vapor for every gallon of paint which was sprayed. From this figure can be calculated the number of cubic feet of solvent sprayed into a tank per hour. Taking this figure in relation to the volume of a tank or area in which the coating is applied, the amount of ventilation can easily be calculated.

"In our work with vinyl coatings we use the figure of 1 percent as the maximum solvent concentration allowable and from this have calculated the size blower required for various size tanks. Ventilation must be maintained during the entire time of application and drying following application to make certain the lower explosive limit is never reached.

"2. It will be noted . . . [that] the density of solvent vapor was given compared to air. In all cases you will find the solvent vapors were heavier than air; therefore, they would have a tendency to concentrate in the lower portion of a tank or closed structure. It is normal practice, therefore, that the suction blowers be operated in such a way that not



Figure 12—Area coated with Saran-type material after nineteen months' service.

only is the turn-over of air sufficient to maintain solvent concentration but also in such a way as to prevent pockets of solvent vapor being concentrated in the lower portions of enclosed spaces. This can ordinarily be accomplished by sucking the air with suction blowers from the bottom of the tank so the circulation of the air is from top manholes or openings and away through the tank and up through blowers and away from the application area. . . .

"3. The third point to be observed is the use of spark-proof and explosion-proof equipment for application of the coating. Electrical equipment and lights shall be explosion-proof, tools and shoes shall be spark-proof. The use of such equipment has been common practice in the application of synthetic coatings for a number of years."

"4. All smoking, matches, fire, flames, or torches should be prohibited within 50 feet of the area where coatings are being applied.

"5. All men working in enclosed areas should wear compressed air-type masks which supply them with a flow of clean air at all times.

	GALLONS							BARRELS		
	5,000	10,000	25,000	50,000	100,000	250,000	400,000	13,500	27,000	50,000
Volume in cubic feet	668	1,336	3,342	6,684	13,378	33,420	53,500	75,800	151,600	280,000
Cubic feet of solvent vapor to make 1% by vol.	6.68	13.4	33.4	66.8	133.6	334.2	535	758	1,516	2,800
Gal. of coating used to make 1% by vol. of solv. vapor in air	0.26	0.52	1.30	2.6	5.2	13.0	20.8	29.4	58.8	108.3
Changes of air in tank per hr. nec. to keep solv. air vol. ratio to 1%	19.3	9.6	3.8	3.8	1.9	0.77	0.48	0.34	0.26	0.14
Gallons of coating sprayed in one hour	5.0	5.0	5.0	10	10	10	10	10	15	15
Time in min. nec. to chg. air to keep solvent to 1% by volume	3	6	16	16	31	79	125	176	235	432
Recommended suction fan to keep the air far below any explosive limit (cu. feet per minute)	1,000	2,000	2,000	3,000	5,000	10,000	10,000	25,000	35,000	2-25,000
Recommended changes of air in minutes to keep solvent fumes far below explosive limit	40*	40*	1.7†	2.2†	2.7†	3.3†	5.4†	3.0†	4.3†	5.6†

*Seconds.

† Minutes.

"In summary, the procedures to insure safe application of volatile and inflammable materials in enclosed areas are as follows:

1. Adequate ventilation with solvent concentration in the air below one percent by volume.
2. Circulation of air to all portions of tank.
3. Prohibition of smoking, matches and flame within 50 feet of application.
4. Use of explosion-proof and spark-proof equipment.
5. Adequate compressed air masks for workmen in enclosed areas."

The application of high polymers from solvent dispersions is usually by spraying. The technique is well established for the coatings described in this paper with the exception of the Saran-type coating. When dispersed in methyl-ethyl-ketone, this material is not well suited to spraying. For this reason, all applications made by the Navy until the late spring of 1951 were by brush. At that time, because a number of large scale jobs were authorized further efforts to spray the material were made. Two reasonably good methods were found, as follows:

- a. Using a Type MBC DeVilbiss external atomizing spray gun with a number 62 air cap and AV-15-AC-N fluid tip. Pressure tank should be operated with about 90 pounds per square inch pressure on the liquid coating (depending on length and diameter of hose) and 90 pounds pressure on the spray gun. A pigmented dispersion of the Saran-type resin in methyl-ethyl-ketone, containing about 15 percent of resin and about 8 percent titanium dioxide, can be sprayed by this method without further thinning.
- b. Using a Type G-6 Eclipse Airbrush internal atomizing gun with a number 44 fluid tip ($\frac{1}{8}$ -inch outside diameter tip). A fluid pressure of 60 to 90 pounds was used with 50 to 60 pounds pressure on the spray gun. Thinning the composition described above with one or two quarts of methyl-ethyl-ketone to every five gallons may be required.

When applied by brush, the Saran-type material should be "flowed-on," not "brushed-out." Excessive brushing may soften undercoats. Actual use has demonstrated that "lifting" of undercoats is not a problem. The resin releases solvent quickly and the deposited solid resin does not redissolve easily.

The Saran-type resin tends to further polymerize when solutions are in contact with iron. Therefore, solutions stored in ordinary steel containers will undergo gelation. This can be prevented by storage in commercially available steel paint containers lined with heat cured phenolic coatings resistant to the dispersing solvent (usually methyl-ethyl-ketone). Good stability up to 20 months has been observed in such lined containers, and would probably extend beyond this period.

Application and storage properties of the Saran-type material are included in some detail because the material is relatively new and its use in this type of protective coating work has not been widespread. Other high polymer type coatings mentioned in this paper have received more widespread attention and

TABLE II—Cost of Applying Tank Coatings

Type of Tank	Cost	Basis
Submarine ballast tank.....	\$1700	Labor and material to clean, stage, ventilate and coat an actual tank (1948).
Railway tank car.....	\$300	Labor and material to gas-free, clean, ventilate and coat 200 cars (1950).
Main cargo tank on ship ¹ 400,000 gallons, 10,000 barrels.	\$9500	Labor and material to clean, stage, ventilate and coat an actual tank during service test (1947).
Main and wing cargo tanks on ship. Two main and four wing tanks, varying from 560,000 to 115,000 gallon capacity. Total capacity 1,460,000 gallons.	\$62,141 ²	Labor and material to clean stage, ventilate, and coat actual tanks (1951).
Tank truck refueler.....	\$200-\$300	Estimate from commercial source (1951).

¹ Initial service test—1947.

² \$10.357 average per tank.

commercial applicators are usually well informed on their behavior.

The question of whether it is economically sound to line gasoline or other fuel tanks with coatings depends upon relative costs. Formerly it has been thought it would be cheaper to allow many such structures to corrode without protection until useless and then to repair or replace them. At present, it is probable original ideas along such lines must be revised. There are cases where current replacement cost now far exceeds original estimates for financing replacement. Again, there are probably cases where material for replacement is difficult to obtain and in such instances, it might be advisable to apply a coating now to extend structure life beyond the originally planned date of replacement.

The cost of applying these fuel-resistant coatings obviously will depend upon so many condition no accurate prediction can be made. Major cost factor will be labor to prepare the metal and apply the coating. Most favorable costs are obtained when considering new equipment because metal preparation is then easiest and no allowance must be included for time lost by reason of taking equipment out of its usual profitable function. Cost information in Table II is intended only as a reasonably reliable guide and cannot be considered firmly established.

It is emphasized that some aspects of the costs in Table II may be considered optimistic by commercial sources, especially because no allowance has been made for indirect costs, such as time out of service and, to a lesser extent, for items such as cost of ventilating and sand blasting equipment. However, commercial coating application contractors and larger industries interested in protecting tanks and other equipment from corrosion usually have such equipment.

In comparison with these coating costs, one Navy ship reported structural replacement costs of \$40,500 after nine years of service. In addition, periodic de-scaling costs of \$5000 each, pump repairs because of excessive wear resulting from abrasion by scale, the necessity of removing large accumulations of sludge and scale from tank bottoms and easier gas-freeing, cleaning and elimination of cargo adulteration are also factors favoring the use of coatings. One commercial estimate for repairs to the tank section of

a clean service tanker after ten years of service is \$200,000-\$300,000.

Other Corrosion Controlling Methods

The author now knows of no method in widespread use for controlling this corrosion other than the use of organic coatings with the possible exception of one instance in which additives may be in use. It is recognized that coatings have certain disadvantages, such as cost and trouble of application and do not represent a perfect solution to the problem. At present, however, coatings represent the only practicable means available and have an added advantage of preventing cargo contamination. This may be of special interest to those interested in bulk shipment of any material to which such coatings are resistant. Table III gives results of exposing 86-octane leaded gasoline to three coatings in lined tanks, in comparison to storage in a clean, mild steel unlined tank. This test was conducted in a five-gallon test tank where the ratio of coated area to volume was 8.8. In larger tanks this ratio would be greatly reduced. For example, in a tank of about 100,000 gallons capacity the ratio would be about 0.26. In practice, therefore, any pick-up by contact with the coating would be almost undetectable, with the possible exception of the polysulfide-type coating.

An attractive idea for controlling this corrosion is to consider additives which might be dissolved in small percentage in the cargo or in the ballast, or both. One beaker trial of sodium alkyl sulfonylaminoacetate was made in this laboratory. In this instance, mild steel panels, cleaned to bright metal were used. One panel was partly immersed for one week in gasoline containing 0.5 percent of the additive and during the next week in sea water with the same amount of additive. After twelve weeks, the panel showed rusting and pitting at the liquid level, and rust discoloration above the liquid level. A second panel was immersed for weekly periods in sea water containing the additive and gasoline with no additive. Rusting and pitting were again found at the liquid level with some rusting above and below the liquid level. From this test it is concluded this additive would not be suitable for controlling corrosion in tanks.

A test⁵ of a proprietary additive has indicated that this approach has merit only if the additive is present in the fuel cargo, the ballast and in the hot sea water injected into the tank for gas-freeing. In this test, the proprietary additive was used to the extent of 0.006 percent by volume in the gasoline and 0.05 percent by volume in the sea water ballast. Mild steel test coupons were installed in the tank. Certain of the test coupons were removed during the period when jets of hot sea water were being used to gas-free the tank. Others remained in the tank at all times. At the conclusion of the test, it was found that the additive had protected the removable coupons. However, the non-removable coupon near the top of the tank had suffered as much penetration as was experienced in a comparison tank where no additive was used and the non-removable coupon near the bottom of the tank suffered an unaccountably increased penetration. From this and apparently from other tests

TABLE III—Effect of Coatings on Gasoline During Storage

COATING	Polysulfide-type	Saran-type	Vinyl-type	None
Octane Rating—6 mo.	85.4	85.7	85.8	86.0
Octane Rating*—12 mo.	85.8	86.2	86.1	86.3
Residue—6 mo., mg/100 ml.	30	4.5	7.5	3.5
Residue*—12 mo., mg/100 ml.	16.4	1.6	2.2	1.2
Accelerated Gum—6 mo., mgs/100 ml.	27.5	3.5	3.5	2.5
Accelerated Gum*—12 mo., mg/100 ml.	14.6	1.2	0.7	0.4

SR-6 leaded fuel used. * Original gasoline replaced by fresh gasoline after first six months. Figures shown for 12 months represent 6 months' exposure to this fresh gasoline.

Coated Area
Volume = 8.8 (5 gallon test tank). Coated Area
Volume = 0.26 (118,000 gallon tank).

the source of this information concludes the particular additive is effective if used in both ballast and fuel but ineffective if hot sea water jets are used for gas-freeing and further that it is less effective in some river and shore waters than in clean sea water.

As an opinion only, the author considers additives of this type probably would be most effective in tanks operating under such conditions as to be always full or nearly full of liquid. It is generally agreed by ship operators that corrosion is less severe in "full" tanks than in tanks which are sometimes only partly full ("slack" tanks).

Another approach to this corrosion problem has been to attempt the introduction of dry, inert gases into the vapor space of the tank. The author knows of no instance where this has been successful and considers that such a method could not be used where water ballast was encountered.

It is understood attempts have been made to use sacrificial anodes and cathodic protection. Both appear to have a serious limitation unless tanks are full, or nearly full, since protection by this means would not be projected into the vapor space. Further, the possibility of hydrogen accumulation if cathodic protection were not well controlled, is said to be a deterrent.

Various inorganic coatings (such as spraying lime on the tank walls with the sea water jets during gas-freeing) are said to be ineffective. However, a coating of Portland cement on tank bottoms has been reported good. Some early failures have been noted and attributed to improper removal of scale or accumulation of oxide before cementing. The author questions whether such coatings would be flexible enough to allow their use on the sides or overhead of ships' tanks.

Coatings of Possible Future Interest

About 500 coating materials have been examined using the laboratory test cycle described in this paper. Certain of these tests were prior to service tests, others were concurrent with the service tests and still others were started after the service tests and are still continuing. Considering those coatings most thoroughly evaluated, it must be concluded that the vinylidene chloride/acrylonitrile copolymer, 1000 centipoise type, is superior to all other air-drying coatings. This is especially true when some exposure to elevated temperatures (175 degrees F) may be encountered and such possibility seems highly probable

in view of the prevalence of mild steaming, or hot sea water gas-freeing procedures.

Present laboratory tests indicate a continuing interest in types of materials similar to those previously described and including proprietary formulations of epichlorhydrin resins (catalyzed, air drying); polysulfide resins mixed with vinylchloride or vinylidene chloride/acrylonitrile resins; high molecular weight vinyl resins; and similar solvent-resistant types. An ideal type material for this use would be a water emulsion coating capable of depositing an air drying film having the same integrity as the present solvent dispersed Saran-type. Such a coating would eliminate much of the trouble involved in applying such a coating. To date, all water emulsion types tried have been unsatisfactory.

Information concerning coating types is presented with some reservation. For the greater part, this laboratory has tested proprietary products and has not been fully informed as to composition. While it is inevitable that broad information becomes available even by this approach, the information should not be interpreted as being specific and it is not intended to imply that a material should be accepted or rejected for this use simply on information as to class of resin used.

Summation

Serious corrosion of mild steel occurs when refined petroleum products, such as gasoline are transported in bulk in tankers. One approach to this problem is to apply organic protective coatings. A program directed by the Industrial Test Laboratory, Philadelphia

Naval Shipyard, Philadelphia, Pennsylvania and sponsored by the Bureau of Ships, Department of the Navy, has shown that coatings based on a vinylidene chloride/acrylonitrile copolymer are suitable for this purpose. These coatings dry by solvent evaporation, and require clean metal surfaces and careful attention to good safety practices during application. When multiple coats are applied to a total thickness of about 0.008 inches, it is estimated the coatings will be adequate for four years against the combined effect of sea water and refined petroleum products, or equivalent corrosive conditions; and that touch-up at intervals of four years will extend the life expectancy of the coating indefinitely. Since the coatings are air-drying and somewhat cheaper than various heat cured materials now used to protect tank car interiors and various types of equipment, it is recommended that they be investigated by industry for such uses.

The opinions expressed in this paper are those of the author and are not necessarily the opinions of the Department of the Navy.

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Isolation of Trolley Bus Negative Return To Prevent Stray Current Corrosion *

By L. HORVATH,¹ H. E. NERHOOD,² S. M. SEIDMAN³ and R. H. TRAVERS⁴

CONVERSION of a street railway system to trolley bus operation presents an opportunity to eliminate associated stray current effects by adopting an isolated negative return. An alternative is the retention of rail return, which avoids investment in negative copper.

In this discussion the object is to show the advantage of isolation as a method for eliminating stray current corrosion; to outline the problems involved in the isolation technique; and to show how isolation unmasks other problems and makes their solution possible.

In two Ohio cities, Akron and Youngstown, corrosion problems incident to transit system conversion were solved by isolation of the negative return from ground. In many ways the two cases are similar. The Akron case is discussed in detail. The Youngstown case is presented by comparison with Akron.

The Akron Story

Metropolitan Akron is a city of 470,000 people with scattered industrial areas which are surrounded by residential sections featuring single and double unit



Figure 1—Akron and suburbs street railway systems of 1921.

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Abstract

When a rail transportation system is converted to trolley bus operation, there is a tendency to continue the use of rails for negative return. In two Ohio cities—Akron and Youngstown—where this was done, the resultant problems, corrosion and otherwise, finally led to abandonment of rail return and isolation of the negative return from ground.

The experience in these cities is reported from the standpoint of two utilities, Ohio Edison Company and The Ohio Bell Telephone Company, whose underground structures were involved. This paper compares corrosion conditions before and after the isolation. The problems which arose during the conversion and those which became apparent after the isolation are discussed.

dwelling. This causes the city to be spread over an area of 243 square miles.

In 1921, Akron had a streetcar system with grounded rail return, the extent of which is shown in Figure 1.

The Conversion Program

During the years 1931 to 1933 the majority of the rail lines were abandoned in favor of automotive bus lines. Figure 2 shows the extent of the streetcar system after this conversion.

A program to introduce trolley bus lines and abandon the remaining streetcar lines was begun in 1941 and completed in 1947. The trolley bus system has continued to grow and now is as shown in Figure 3.

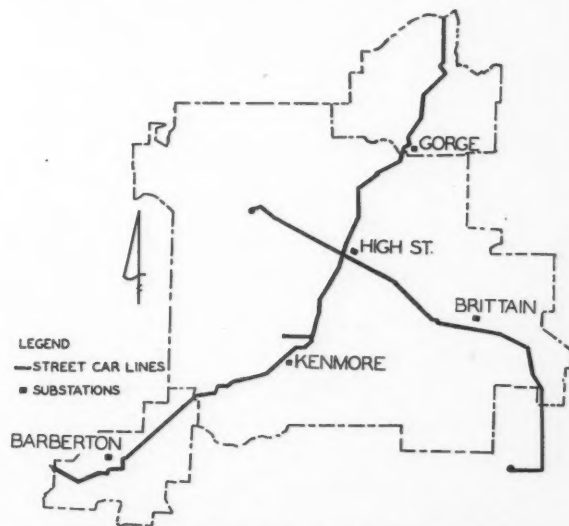


Figure 2—Akron and suburbs street railway systems of 1933.

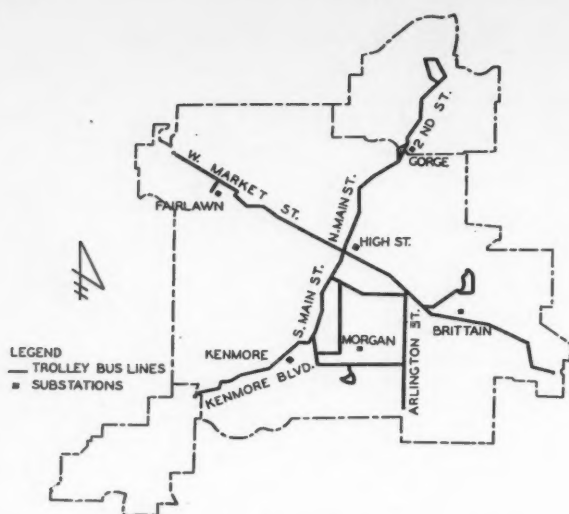


Figure 3—Akron and suburbs trolley bus routes of 1951.

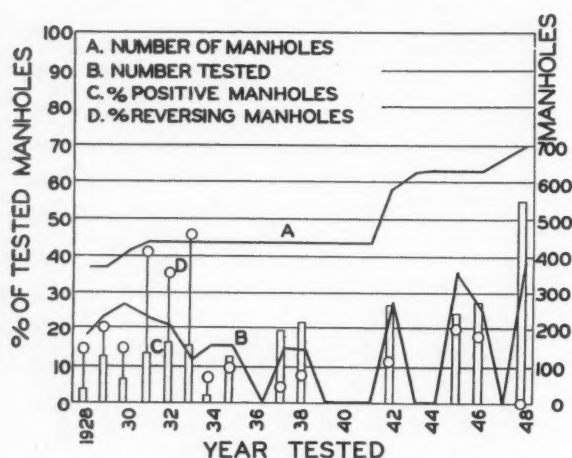


Figure 4—Routine survey test results—1928 to 1948.

During the 1941-1947 period, old streetcar rails not in use for streetcar service were removed because of street improvement or scrap drives. At the present time practically all rails have been removed.

Power for the trolley bus system is furnished from rotating machinery which formerly supplied power to the streetcar system. The positive trolley network is sectionalized by feeder areas. Overload type circuit breakers are provided in the feeders at the substations. At some locations the extremities of positive feeders from different substations are tied together through automatic circuit breakers. The negative feeder system is a single grid tied solidly to the negative bus at each substation and at a few selected locations in this negative grid mechanical disconnecting devices have been provided to isolate sections for fault location.

Corrosion Experience

Sheaths of power and telephone cables corrode unseen in their conduits and this corrosion is sometimes undetected until a cable failure occurs giving an op-

portunity to view the corroded sheath. An earlier indication can be obtained by electrical tests of the cable sheath and its environment. Both kinds of indication, failures and tests, constitute corrosion experience.

It has been the general practice of The Ohio Bell Telephone Company for many years to make an annual routine survey of electrolysis conditions of its underground cables. For Akron, the results of these surveys for the period 1928 to 1948 are summarized in Figure 4. This data was compiled on the basis that the "Percent of Manholes Positive" and "Percent of Manholes Reversing" would indicate changes in the status of the drainage ties. For example, the improvement shown in 1930 as compared with 1929, coincided with a readjustment of drainage in the downtown section.

It is apparent from the data that deterioration beginning in 1931 extended through 1933. During this period the program for replacement of streetcar lines with automotive bus lines upset drainage conditions. The improvement in 1934, coincident with changes in drainage, is clearly indicated. These changes included installation of insulating joints in the sheaths of all telephone cables where they enter telephone central office buildings in order to isolate the cable sheaths from all other underground structures. Other important changes in 1934 were the installation of a forced drainage rectifier in the southern part of Akron and readjustment of the transit substation operating potentials. Conditions shown for 1942, 1945 and 1946 reflect the adverse effect during the program of conversion to trolley bus operation. The 1948 figures show the condition after the conversion program was completed and the negative return isolated. It should be noted, in this case, that the high percentage of positive manholes does not have the same significance under non-stray conditions as it did under previous conditions, since all sheath currents are of a much lower magnitude and drainage is no longer the prime consideration.

The record of Ohio Edison Company corrosion experience during the 1928 to 1938 period is somewhat obscure. During these years little attention was paid to corrosion conditions except when failures occurred. The number of failures began increasing in 1937 and 1938 and by 1941 considerable attention was being paid to electrolysis conditions. Subsequent to this, Ohio Edison and The Ohio Bell Telephone made five or six joint surveys and similar conditions were found on the two cable systems. In general the power cables were tending to carry more stray current because of their large diameter and thicker lead sheath and because these cable sheaths were tied to the 4160-volt neutral at every available point, whereas the communication cables were isolated from other structures as much as possible.

Data on corrosion cable failures of The Ohio Bell Telephone Company are not available for the period prior to 1945, but from 1945 to 1949, failures averaged about six per year without a definite trend.

Basic Considerations

Prior to 1931, the electric power system and the transportation system in the Akron area were owned and operated by a single company. In 1931, a reorgani-

zation put the power company and the transit company under separate management but the Ohio Edison retained ownership of the DC generating equipment.

Thus the rotating machinery, which supplied power to the DC transit system, remained in use in several of the power company's substations. The negative busses at each machine had been connected to the substation ground and to the rails of the streetcar system.

The AC distribution system in Akron is a 4160-volt wye system with a grounded neutral connection. This 4160-volt Neutral is carried on poles and through the underground system along with the phase wires. In some places this Neutral is a bare copper conductor in the underground system. It is completely interconnected from one substation to another, so that it forms a copper grid over the entire area. This grid is grounded to substation groundmats, water pipes and ground rods. Prior to 1947, it was tied also to the streetcar rails.

In this manner, the Negative and Neutral became thoroughly inter-connected throughout the area and one of the effects of these ties was to supplement the conductivity of the rails, but there were several adverse effects. This practice exposed the power cable sheaths to DC rail potentials and introduced DC current in distribution transformer windings, causing overheating and saturation.

It overdrained the power cables and water pipes near the substations, thus creating a negative environment in which other substructures must become anodic, or compete for drainage. It made it difficult to readjust drainage in conjunction with transit arrangements.

When, in the 1931-1933 period, several streetcar lines were discontinued, a drainage problem was created that was not entirely solved by the accompanying drainage changes. During this period there was insufficient evidence of corrosion to prove the need for extensive changes in the negative grounding system but evidence gradually accumulated in succeeding years.

A factor that weighed heavily on the side of deferring action was the fact that the transit system was still in a transition stage and the ultimate abandonment of streetcar lines might eliminate the problem. When the transit company announced a trolley bus program in 1940 and proposed to remove all rails the possibility of eliminating the problem took definite shape. The program was scheduled to be completed in 1942 but wartime shortages delayed completion until 1947.

What happened in the years 1941 to 1947 gave ample evidence of the difficulties involved in grounded negative return operation of a trolley bus system. The remaining rails were used temporarily in parallel with the negative return and corrosion increased markedly during this period. Field tests indicated that with the Negative grounded at many locations the negative return circuit had from four to six times the resistance of the ground path. This resulted in the major portion of DC transit current flow through the earth and as discontinuities in substructure arrange-

ments were encountered, severe corrosion conditions became evident.

When the program was completed in 1947, there were still locations where the cables were exposed to stray currents. This condition was traced to the interchange of current between the grounded Negatives of the DC substations. Not until these grounds were removed at all substations except High Street, were the stray current effects from normal transit operation eliminated.

Isolation of Negative Return

There are several schools of thought regarding the grounding of DC Transit systems, the four most common being:

1. The fully grounded system, in which all substations are grounded and connected to the rails, which in turn are used as the negative return. This is the one most familiar to the majority of corrosion engineers because it is used in most street railway operations. Substation machinery and outside plant has been designed for this type of operation. When a trolley bus system uses existing streetcar rails for a negative feeder system, these rails must be kept intact to provide good conductivity, otherwise tremendous stray currents will be introduced into the earth.
2. The systems in which the negative return is grounded only at the substations. In this case the magnitude of stray current is reduced by a substantial amount; however, troublesome stray currents are produced by the interchange of current between the grounds of the various substations.
3. The uni-grounded system, with the negative return and all substations except one isolated from ground. This removes all stray current from earth except during accidental grounds, and the single central ground serves as a protection ground for the system.
4. The completely isolated system, in which the entire system is devoid of ground contacts. This is a system which is free of stray current but lacks a protection ground for the substation equipment insulation.

The Akron and Youngstown systems are of the uni-grounded type.

Process of Isolating

The process of isolation of the negative was, more or less, a step-by-step procedure with each succeeding step being determined after observing the results obtained by the preceding steps.

The Grant Street transit line in Akron first to be converted to trolley bus operation was a line which previously had been converted to automotive operation and many rails from the original streetcar line had been removed. Because the rail was not available in this case for use as negative return, installation of negative feeder copper was necessary. When installed, the negative feeder and the negative trolley were insulated from ground in exactly the same manner as the positive feeder and trolley.

East Market Street, the second line to be converted, was one of the two remaining streetcar lines. In this case a street improvement program was involved and removal of the rails was very desirable. As a result, the Negative was handled in the same manner as on Grant Street.

It was shortly after the installation of the first two

trolley bus lines that considerable interchange of DC current was noted over the 4160-volt neutral system and other grounded structures in parallel with this Neutral. These currents were causing corrosion difficulties, particularly in the downtown area, where the largest concentration of DC rotating machinery is installed. An attempt was made to balance out some of these flows by installing heavy ties between the negative feeder system and the 4160-volt Neutral in four or five places in the downtown area.

As the program proceeded it became apparent these ties between Negative and Neutral were objectionable from many standpoints, especially that of corrosion. A more desirable solution was seen in removing all ties, thus allowing the DC system to become a floating system with no ground connection.

This solution was impractical because of the low insulation level on the series fields of the rotating machines and it was decided instead to maintain a single heavy ground at High Street, the largest substation, which is in the downtown area and is the approximate electrical center of the trolley bus system. This connection was made through a 1500 ampere shunt with a Leeds & Northrup micromax current recorder connected to it.

All other known connections between Negative and ground were removed. After this was completed, it was discovered that the current recorder still indicated current flows in what was supposed to be the only ground connection on the system, which was definite proof that other grounds still existed. Further investigation confirmed this fact and two types of ground connection were found.

One type of ground which was prevalent in substations and in the transit company's car barn area consisted of station equipment such as relay coils, indicating lamps, space heaters, air compressor motors, lathe motors, etc., which were connected from Positive to ground. In order to eliminate this type of ground, these were all reconnected from Positive to Negative. One characteristic of this type of ground is that the flow of current at the central ground point of the system is always from the earth and 4160-volt Neutral to the Negative.

The other type of ground was found to be additional connections between negative and ground. A test was devised to locate these remaining connections whereby a test current of approximately 40 amperes DC was forced to flow out over the negative system to the unknown ground. This flow was traced by using a ladder truck and a DC tong-type ammeter.

After removing faults located in this manner the Negative was energized to 700 volts by connecting one of the railway motor-generators to it. At this potential it was found that a small amount of current would flow, which was assumed to be due to insulator leakage and wet tree grounds. At this point the condition of the system was accepted as satisfactory and no further attempts to improve isolation were made.

From time to time accidental grounds occur on this system and when they do, the Leeds & Northrup recorder tells the story. It has been learned from experience that the direction and magnitude of this current flow are clues to the general area in which the

accidental ground has occurred. Varying the voltage levels at various DC substations will sometimes affect the flow of current in the central ground and this data furnishes further clues to the fault location. Extensive testing was done to establish these characteristics. Experience has shown in nearly all cases that when a fault occurs on the DC negative system, the central ground is carrying an AC component of current in addition to the DC fault current. This permits the use of a ladder truck and an AC tong-type ammeter to trace the flow of AC over the negative network while the transit system is still in operation. Most faults have been located in this manner.

Occasionally faults occur on the positive feeder system at such a point and in such a manner that the fault current is less than the load current. When this happens the overload protective equipment may not operate and high currents may flow over the underground structures and 4160-volt neutral network until the fault can be located and cleared. To protect the communication cable system from this hazard it has been found desirable to rearrange drainage circuits and install an automatic drain switch in the downtown area to drain these cables to the 4160-volt Neutral at a point close to the station where the central ground is maintained. Figure 5 schematically illustrates this situation.

Results of Isolation

In 1947, after the isolation of the Negative was completed, recording meters were set at strategic locations on all underground structures and 24-hour readings were taken of potentials from structure to earth. Typical of the test results is the reading obtained on telephone cables at the corner of Exchange and Main Streets. As shown in Figure 6, which compares the 1947 test with one made at the same location in 1945, the stray current fluctuations had disappeared and the average potential had become slightly positive. In general, the 1947 tests detected some minor fluctuations in structure-to-earth potentials but these variations were not related to normal transit operation. They were found to be due to a number of separate sources whose influence was highly local in nature. It was apparent therefore that

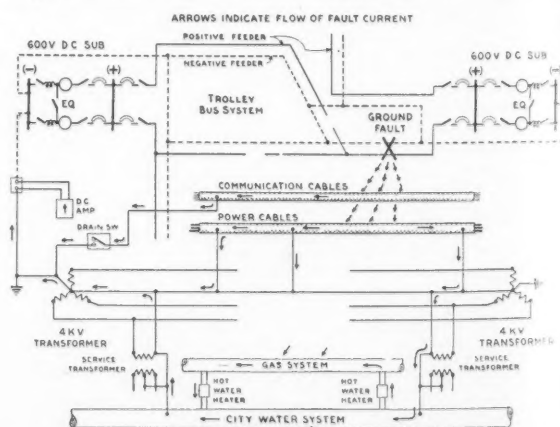


Figure 5—Schematic diagram showing relationship of 600-volt trolley system to other utility systems.

under normal operation the transit system had been eliminated as a source of stray currents, leaving some minor problems which remained to be studied.

To test the effects of abnormal operation of the transit system, stray currents were introduced in the northern and southern sections of the transit area, by operating grounded maintenance equipment at high load currents. The magnitude of the stray currents was measured by the recording meter in the ground connection at High Street Substation. A simultaneous reading was taken of the drainage current in the automatic switch which ties the telephone cables to the 4160-volt Neutral near High Street Substation. At the same time a cable-to-earth potential measurement was made at a point near this substation. These tests, made in 1952, and shown in Figure 7, indicate that the telephone drainage connection carries about 7 percent of the stray current and that the telephone cables are driven positive to earth by abnormal stray currents at a rate less than $\frac{1}{4}$ -volt per thousand amperes. Similar effects would be encountered in the case of a ground fault on the transit system.

To indicate the definite absence of stray currents after isolation, recording meter tests were made in 1952 of the ground potential at each of the outlying substations with respect to the High Street Substation ground. Telephone cable conductors were used to extend the meter terminals to the test points. These tests, taken with a 10,000 ohms/volt meter, indicated a total variation of not more than 0.2 volt during normal operation. Figure 8 shows the readings at Brittain Substation in 1952 compared with similar tests in 1933 and 1921.

Failures After Isolation

Corrosion failures have not disappeared since the elimination of transit stray currents. In the four years since the isolation was completed, no power cable failures have occurred in the several downtown areas where numerous failures had occurred before, however, in a new location on the edge of the downtown area several failures have occurred since isolation. This will be discussed later as the "Blackstone case." Prior to the installation of the new telephone drainage circuit to the High Street Substation, one telephone cable failure occurred which was due to transit stray current from accidental grounds. No further cable failures of this type have occurred since the drainage circuit went into operation.

A number of other telephone and power cable failures were experienced which were found to be due to such causes as miscellaneous local stray currents and unfavorable duct conditions such as carbonaceous deposits, wet environment and differential aeration. The conditions which caused these cable failures are still under study and are being corrected in a systematic manner.

Investigations of Remaining Problems

With the completion of isolation, Akron became, in effect, a non-stray area. The investigation of any corrosion problem still present, therefore, requires different methods of approach than before. Three of the

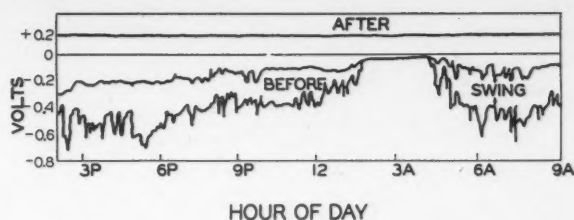


Figure 6—Cable-to-earth potential, corner Main and Exchange, before and after isolation.

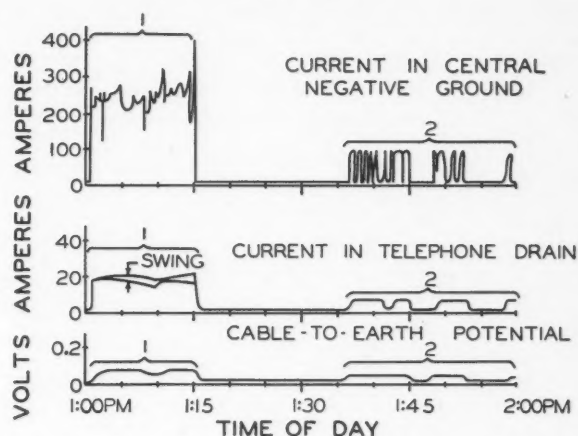


Figure 7—Effect of abnormal operation on telephone cable drainage and potential: 1. Gorge coal hauling locomotive. 2. Kenmore welding machine.

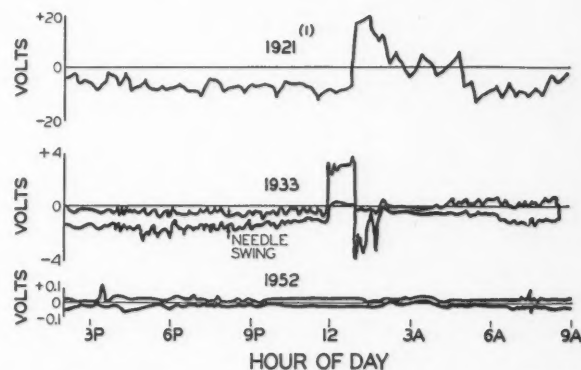


Figure 8—Brittain substation ground potential referred to High street substation ground in 1921, 1933 and 1952.

more interesting problems which have been investigated since isolation are discussed:

The Blackstone case had to do with the power cable failures in the vicinity of the Blackstone central office, the only telephone central office in the downtown section. (See Figure 9.) Tests made in 1948 and 1949 revealed local stray current, some of which was identified as caused by grounded battery supply to private telephone switchboards. This source was eliminated by the telephone company. Retest showed that part of the area involved was improved but a duct survey disclosed that there was an anodic area close to the Blackstone Central Office. This effect was traced to an unsuspected cofferdam surrounding the Blackstone building below the ground level and iso-

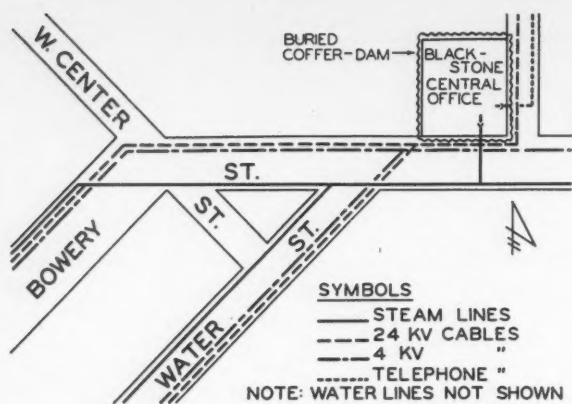


Figure 9—Blackstone Central Office and vicinity.

lated from the building steelwork. Bonding the central office ground to the cofferdam permitted isolating the central office ground from other substructures and prevented current from leaving the Blackstone building over these structures. Retest indicated that an improvement in corrosion conditions has resulted. If further improvement is found necessary, the means are available to completely solve this case.

The Gorge Bridge case has to do with telephone cable failures at the Gorge Bridge which crosses the Cuyahoga River near the Gorge Electric Power Plant. This is a case of long standing and one which was obscured by the presence of transit stray currents until isolation was accomplished. Tests after isolation indicate the corrosion was the result of several factors, such as: leakage of current through duct joints to the grounded bridge structure; the presence of cinder fill near the bridge; the presence of water in ducts. In 1948 water was drained from the ducts by means of an additional manhole at the east end of the bridge and this did much to improve the unsatisfactory condition. Further improvement is anticipated by proposed cathodic protection using a rectifier as the power supply source.

The West Market Street case affects both power and telephone cables. The area involved is residential and the case involves a succession of anodic and cathodic areas along a heavily traveled main thoroughfare. There is no fluctuation of potentials. Tests indicated probability of a local cell condition requiring cathodic protection. The telephone company plans to use a rectifier as a DC source and to distribute the drainage to all manholes by means of the aluminum sheath of a future Alpeh cable. The Edison Company is also planning a type of cathodic protection.

The Youngstown Story

In Youngstown the history of the transit and power systems is very like that in Akron. Reorganizations in 1931 resulted in power systems in both cities becoming part of Ohio Edison Company. The transportation company in Youngstown became an affiliate of the transportation company in Akron, both being under the same general management.

As in Akron, Ohio Edison owns the DC substation equipment. Conversion of the two transit systems into trolley bus systems followed the same pattern in general.

One significant difference in Youngstown was that in certain sections of the city, the trolley bus lines used the old rails as a negative feeder for a time. Deterioration of the rails in the street finally produced such severe conditions, both with respect to corrosion and to maintaining satisfactory operating voltage on the trolley system, that negative feeders were installed in these areas.

After the isolation of the trolley negative in Akron was completed, the same procedure was followed in Youngstown. This system was isolated early in 1948 and during the following summer, a large joint electrolysis survey was conducted with all interested utilities, including several railroads, participating.

It was found during this survey that stray currents from the Youngstown transit system had been entirely eliminated. However, there is an electric freight railway which operates into Youngstown and stray currents from this source were detected. Several other stray current problems incidental to steel mill operation were uncovered and analyzed. Some problems remain and these have been scheduled for further investigation.

Conclusions

Experience with isolation of negative return in Akron and Youngstown certainly shows that normal transit stray currents can be eliminated in the ground, thus putting an end to one important type of corrosion problem.

It has been demonstrated that the absence of stray current permits the study of other corrosion problems which may have been concealed by the previous presence of stray current. These conditions may also in many cases have been rendered non-destructive by the cathodic influence of the transit stray currents.

In summary then, isolation by the uni-grounded negative return system is a practical solution to the stray current corrosion problem, although its use necessitates associated steps to control other types of corrosion. It has also been shown that the uni-grounded negative return meets, in a practical way, the protection requirements of the power equipment.

Full appreciation of the advantages of isolation requires consideration of the alternatives. When rails are retained for negative return, they are buried below the road surface where maintenance of rail joints becomes impracticable. Even though their bonding may be good at the outset, corrosion of the rails and bonds will gradually create discontinuities in the rails, causing heavy stray currents at unknown locations. More serious effects are caused by man-made discontinuities. It is hard to make contractors realize that the buried rails cannot be cut indiscriminately to put in an entrance pipe or sewer.

Retention of substation grounds after rail removal creates a difficult drainage problem. The structures affected by the stray currents may be at a great distance from the substation creating this current and

drainage to the substation ground becomes impractical. Forced drainage under these conditions may involve currents of high magnitude with rapid changes in magnitude and direction. Coping with such conditions without adversely affecting neighboring structures requires joint drainage or self-adjusting rectifiers. This is a difficult procedure at best.

Compared with these problems, the situation encountered where isolation by the uni-ground method is employed is ideal and the problems it presents are minor.

Results such as outlined in the above discussion can be achieved only by harmonious coordination of the efforts of all parties involved. Elimination of the stray current problems in both Akron and Youngstown and the design of the rearranged drainage circuits was greatly facilitated by the wholehearted cooperation of the two transit companies.

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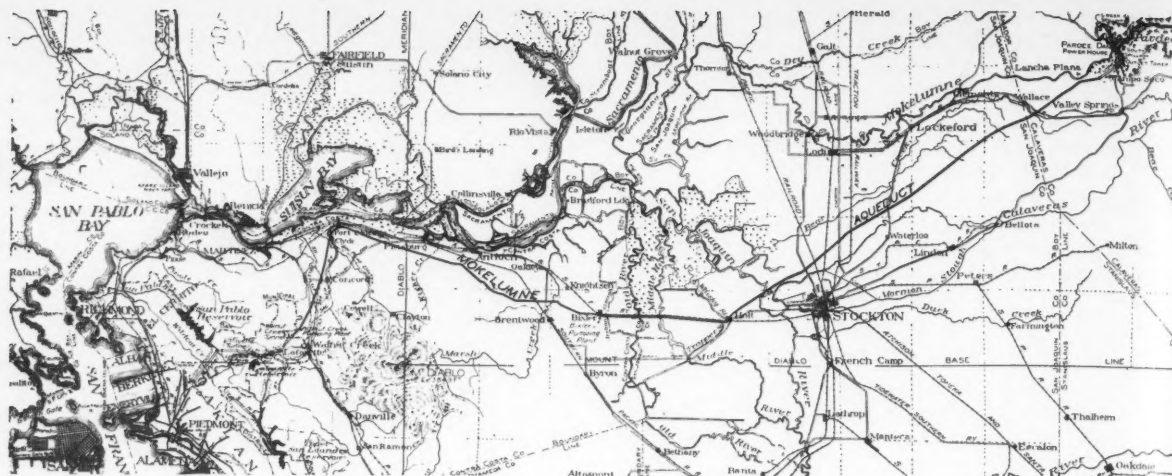


Figure 1—Routes of aqueducts serving San Francisco Bay area.

Interconnection of Pipe Lines Having Various Coatings★

By DAVID HENDRICKSON

Design Factors in Aqueducts

IN THE DESIGN of large steel aqueducts, one objective is to prolong the useful life of the structures. This involves selection of a protective coating which should insulate the steel from corrosive soils and also from stray direct current. It must withstand abrasion during construction and soil stresses during its entire useful life. It must also be free from organic matter which will deteriorate in time and impair its insulating value.

Early protective pipe coatings were felt impregnated with either asphalt or coal tar. In a few years this type of coating develops cracks caused by soil stresses as well as stone punctures and other mechanical ruptures. In order to protect the exposed metal in the cracks, cathodic protection is usually applied to prevent corrosion.

In an effort to increase the life of a steel aqueduct a concrete coating is sometimes used. This coating will withstand soil stresses. However, it is a very poor insulator. Stray railway current and stray current from nearby cathodic stations easily pass through it. Concrete coated steel pipes will generate a galvanic current when interconnected with steel pipe having a bituminous or other coatings which may develop cracks or holidays and expose the metal. This galvanic potential is due to the alkaline environment created by the concrete coating on the steel pipe.

The first serious trouble caused by interconnecting



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concrete coated and bituminous coated steel pipe occurred on the Mokelumne Aqueduct near the city of Walnut Creek, in Contra Costa County, California. Investigation was made in this area and at all other cross connections of the Mokelumne Aqueducts. Heavy galvanic currents were generated at all cross connections where the soil resistivity was low. Currents as high as 80 amperes have been encountered. The aqueducts had to be isolated by installing insulated flange couplings.

Description of Installations

The First Mokelumne Aqueduct was installed during the years 1926-1929. The Aqueduct is 93.85 miles long including tunnels. The steel portion is 81.16 miles long. The diameter varies from 61 inches to 65 inches and the steel plate varies from $\frac{3}{8}$ -inch to $\frac{1}{2}$ -inch thickness. The river crossings are $\frac{1}{2}$ -inch by 54 inches in diameter. The aqueducts extend from

★ A paper presented at the Seventh Annual Conference, National Association of Corrosion Engineers, New York, New York, March 13-16, 1951.

Abstract

This article deals with the design of concrete coated steel aqueducts interconnected with aqueducts with bituminous coating. The galvanic current generated by interconnecting the two aqueducts with different coatings is shown in a specific case. The proper method for isolating these aqueducts is discussed as well as the results of trying to isolate the two pipe lines by installing insulating joints within a network of interconnecting pipes. Test data are given on forced drainage on these incorrectly placed insulating joints in order to reverse residual galvanic currents in the pipe network. The reason operating experience should not overrule recommendations based on electrolysis investigation is given. The AC method, developed for locating accidental short circuits in control piping, conduits and other metallic connection is given. A comparison based on soil resistivity is made between the Mokelumne Aqueducts and the Hetch Hetchy Aqueducts in galvanic currents generated by interconnection. Precautions in the form of a soil survey were taken by the Hetch Hetchy engineers. Insulating joints were installed in their first aqueduct at strategic points. Test data are given on these insulated joints after 17 years of service. Good results obtained by following recommendations based on electrolysis surveys for the pipe coating have been well justified. Accidental short circuit between the two Hetch Hetchy Aqueducts at the San Joaquin Valve House was discovered by the preliminary electrolysis survey after the installation of the Second Aqueduct. The misconception of some engineers that a welding machine grounded to one aqueduct may be used just as effectively on the adjacent aqueduct without ill effect has resulted in much disregard for the recommendations made by the electrolysis engineer. Recommended precautions are set forth in the conclusion of the paper.

the foot hills of the Sierra Nevada mountains to the east side of the San Francisco Bay. The underground portion of the steel pipe has a single wrap of bituminous impregnated felt. (See Figure 1.)

The Second Mokelumne Aqueduct parallels the First Aqueduct. The steel plate varies also from $\frac{3}{8}$ -inch to $\frac{1}{2}$ -inch in thickness. The maximum diameter is 68 inches I.D. The inside of the steel pipe has a $\frac{1}{2}$ -inch spun concrete lining. The outside of the steel pipe has $\frac{3}{4}$ -inch concrete coating. This aqueduct was completed in 1949.

A literature search did not reveal that trouble had been encountered elsewhere by interconnecting concrete coated steel pipe with a bituminous coated steel pipe. Inquiry was made throughout the state of California and the matter was reported at the national convention of the National Association of Corrosion Engineers at St. Louis in April, 1950. None of the inquiries brought in reports of similar trouble.

The City of San Francisco, however, has recently completed a second aqueduct across the San Joaquin Valley as far as Oakdale. These aqueducts are known as Hetch Hetchy Aqueducts No. 1 and No. 2. This new aqueduct is concrete coated, the same as the Second Mokelumne Aqueduct. The First Hetch Hetchy Aqueduct is bituminous coated. Similar galvanic currents were generated when a cross connection was made between the two Hetch Hetchy Aqueducts, but of lesser magnitude. Studies have been made on these aqueducts for the purpose of comparing the magnitude of galvanic currents generated with those of the Mokelumne Aqueducts.

The Hetch Hetchy Aqueduct begins at Early Intake on the Tuolumne River, 12 miles below O'Shaughnessy Dam, water from the reservoir flow-

ing this distance in the natural riverbed. From Early Intake the aqueduct extends 138 miles to Crystal Springs Reservoir in San Mateo County, the Mountain, Foothill and Coast Range Tunnels accounting for about half the length.

That portion of the aqueduct across the San Joaquin Valley is known as San Joaquin Pipe Line No. 1 and extends $47\frac{1}{2}$ miles between the Tesla Portal and the Oakdale Portal. The diameter varies from 58 inches to 66 inches in diameter. The plate thickness varies from $\frac{5}{16}$ -inch to $\frac{1}{2}$ -inch. It has a bituminous coating, details of which are given below. The pipe line was completed in 1932.

The Second San Joaquin Pipe Line parallels the First. The diameter of the concrete coated steel pipe is $62\frac{1}{2}$ inches I.D. with a concrete spun lining. The plate thickness of the steel is $\frac{1}{2}$ -inch. This steel pipe was installed from the San Joaquin River east to the Oakdale Valve House. West of the San Joaquin River to the Tesla Portal a lock joint concrete pipe was used. This concrete pipe has a steel cylinder. This aqueduct was completed as far as Oakdale in 1949.

Test Data Are Taken

The First Hetch Hetchy Aqueduct has eight insulated flanged couplings located at railroad crossings and at the San Joaquin River crossing. These various sections of the bituminous coated aqueduct were connected by means of a cable to the new concrete coated aqueduct to obtain test data. Current and potential measurements have been made and the soil resistivity determined for each section. These data will be given later.

A graph of current pickup and discharge is shown in Figure 2. It will be noted that current discharge is very heavy near Walnut Creek at a point marked "Leak Area." This galvanic current was reduced to a fraction of an ampere by the installation of insulated joints.

At Bixler the insulated joints were installed in the cross connections instead of the main aqueduct as at Walnut Creek. Valves in the cross connections permitted installation of insulated joints without a shut-down of the aqueducts.

Because of interconnecting pipes and conduits between various valve structures, control building and pumping plant, many short circuits had to be cleared but still the current was only reduced about 50 percent. Galvanic current, which continued to flow after all apparent short circuits had been cleared, will be referred to as a residual galvanic current.

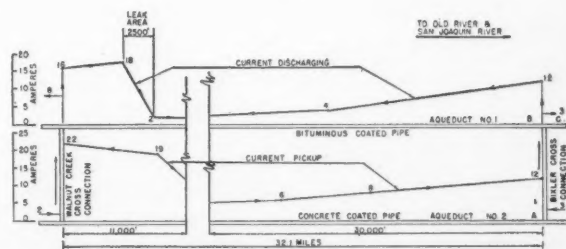


Figure 2—Schematic diagram of cross connections of the Mokelumne Aqueducts showing galvanic currents generated.

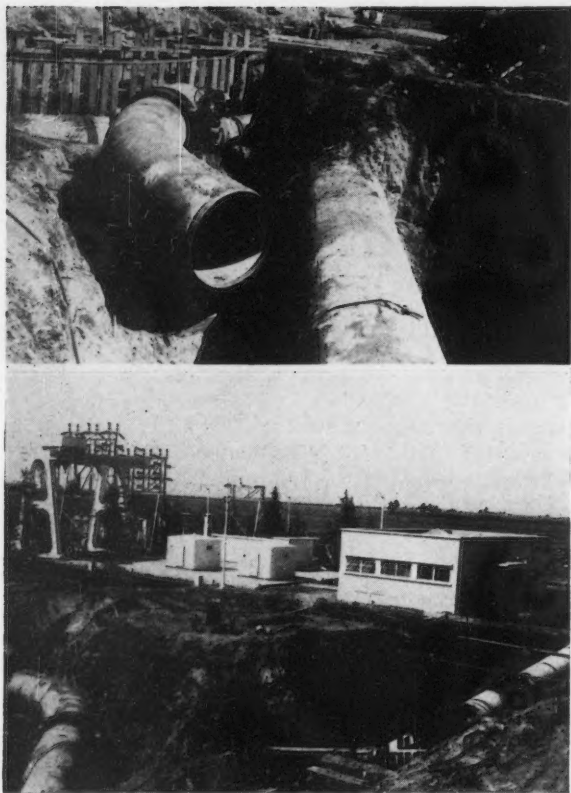


Figure 3—Installation of cross connections of the Mokelumne Aqueducts at Bixler.

Ground Water Causes Current

In the Bixler area ground water is just a few feet below the surface and has a low resistivity. This, coupled with the several concrete valve structures and several sections of concrete coated pipe all connected to the bituminous coated pipe, accounts for some of this residual galvanic current.

It is apparent that insulating flanges also should have been installed in the main aqueduct at some distance from all of these structures and the interconnecting pipes at the Bixler Pumping Plant. Attempts were made to reverse this residual galvanic current by forced drainage on Aqueduct No. 2 at the point marked "A" on Figure 2.

It is estimated from test data that about 70 amperes would have been required to reverse the entire galvanic current at this location by forced drainage. The problem of interference current drainage to the suction and discharge piping at the Bixler Pumping Plant made this plan impractical. Insulated joints were later installed and the residual galvanic current was reduced to less than one ampere.

A. C. Method of Locating Short Circuits

The problem of quickly locating short circuits, caused by conduits and other piping in the valve house and appurtenant structures between the two aqueducts, was solved by an A. C. method. A low potential of about 10 volts AC, 60 cycle was connected between the two aqueducts and the current limited to 100 amperes for test purposes.

By this method each conduit, pipe or metallic connection could be checked with a hook-on type AC ammeter. For large pipe a special design of split-core transformer was used. Each measurement required a few minutes only. When there are many short length special pipes and fittings, this method will save a lot of time.

Test Data

A preliminary electrolysis survey has been made on the Hetch Hetchy Aqueducts subsequent to the installation of the Second Aqueduct as far east as Oakdale. The First Hetch Hetchy Aqueduct has bituminous coating and the Second Aqueduct has a concrete coating. A temporary connection between the two aqueducts was made at Oakdale in order to transmit more water to San Francisco while the remainder of the Second Aqueduct was being constructed.

Current measurements were made between the two aqueducts at Oakdale by means of cable and shunt before the pipe connections were installed. The current varied slowly back and forth between 3.0 amperes and 3.7 amperes. The cycle from maximum to minimum current was of several minutes duration. As there is no stray railway current in this area the cause of this variation has not been determined. The soil resistivity in this area varies from 500 to 15,000 ohm cm.

Other isolated sections of the First Hetch Hetchy Aqueduct were connected to the new concrete coated aqueduct for the purpose of obtaining test data. The connections were made with a No. 6 AWG cable and shunt. The open circuit potential between the two aqueducts, the current flow and soil resistivity of the various sections are listed in Table I.

On the Mokelumne Aqueducts, however, the current and potential values between the aqueducts were much higher. The values are listed in Table II.

The potentials in Table II on the Mokelumne Aqueducts were taken across the insulated joints. The current values were those which flowed when a metallic circuit was made with a No. 2 cable and shunt around the insulated joints. Part of the current and potential values are due to cathodic stations in areas near insulated joints.

Hazard Is Created by Currents

The above tabulations of galvanic currents generated between the two steel aqueducts, one with a

TABLE I

Location	Soil Resistivity Ohm Cm	Open Circuit Potential	Current Amperes
Oakdale Valve House...	500 to 14,460 ohm cm	242 M.V.	3.0 to 3.7 A
Station 74.00.....	970 to 2,000 ohm cm	311 M.V.	4.2 A
Station 84.19.....	300 to 3,200 ohm cm	150 M.V.	2.6 A
Station 91.67.....	200 to 1,440 ohm cm	310 M.V.	4.18 A

TABLE II

Location	Soil Resistivity Ohm Cm	Open Circuit Potential Millivolts	Current Amperes
Walnut Creek West...	600-1000	1000	77
Walnut Creek East...	200- 800	910	46
Bixler West.....	350-10000	165	16
Bixler East.....	350-1000	160	10.8
Bolt.....	1050-1550	380	17.2
San Joaquin River West	1050-1550	620	52.0
San Joaquin River East	100- 700	1010	80.0

concrete coating, the other with a bituminous coating, give some idea of the hazard created when they were connected. It is obvious they had to be isolated to protect exposed metal of the bituminous coated aqueduct. This was apparent on both the Hetch Hetchy and the Mokelumne Aqueducts.

It is of interest also to note that an appreciable amount of galvanic current will flow among the various isolated sections of the Hetch Hetchy Aqueducts. As previously stated, the First Aqueduct has eight insulating joints which break up the long line currents. These insulating joints were tested last summer after 17 years of service. They were found still effective.

When these insulated joints were short circuited as much as 2.4 amperes would flow between sections near the San Joaquin River. In the sections where the soil resistivity is high the current flow between sections is less than one ampere.

On the Second Hetch Hetchy Aqueduct no insulating joints were installed. No investigation has been made to date to determine the magnitude of any long line galvanic currents generated between areas of high and low soil resistivities. A concrete coating on a steel aqueduct will not prevent the generation of long line currents. A check on these long line currents will be made after completing the portion of the aqueduct east of Oakdale.

Disintegration of Concrete Coating by Long Line Galvanic Currents

A concrete coating on steel pipe has been assumed to be the most durable. However, some weak points have been discovered recently. The disintegration of the concrete coating was discovered on the Crockett Pipe Line after fourteen years of service. Investigation revealed that the disintegration was due to long line galvanic currents.

This is a 25-inch steel pipe with a Concrete coating. No provisions were made to insulate this pipe in soils of low resistivity. The result was that long line galvanic currents were generated between soils of high and low resistivity.

Current discharge areas were located in small valleys in the foot hill area on the east shore of San Francisco Bay. The first trouble encountered was caused by only one-half ampere discharging in a little valley. This small current disintegrated the concrete coating; this resulted in leaving a portion of the pipe bare. An additional galvanic current was then generated between this bare portion and the surrounding concrete coated pipe. In other words, there is a compound galvanic action composed of the original long line current between different soil types and the local action at the disintegrated or bare sections. These currents are both discharging at the same place.

This compound galvanic action does not always confine the corrosion to pits. In one case an area of ten square inches became so thin that it burst under a pressure of approximately 120 psi. In this case the aqueduct had to be shut down and drained before it could be repaired. Figure 4 shows the effect of this type of corrosion.

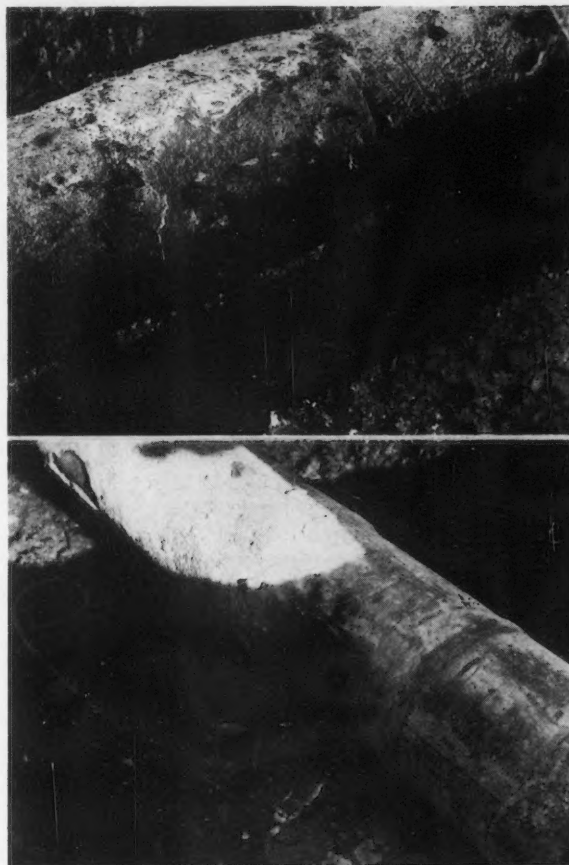


Figure 4—Disintegration of concrete coating on the Crockett pipe line.

If this same type of failure occurred on a large aqueduct with a capacity of a million gallons per mile, it could flood a lot of land. Besides the flood damage, repairs would be difficult as equipment might bog down in the flooded area.

Soil Surveys Are Worthwhile

A preliminary soil survey usually pays big dividends if the design of the aqueduct is based on soil conditions.

The soil survey made 17 years ago on the Hetch Hetchy First Aqueduct has been well justified. There have been only five leaks which can be attributed to corrosion during these 17 years. No cathodic protection has been used to date on the San Joaquin pipe lines. In soils of low resistivity the pipe had a double wrap of bituminous coating covered with a wire reinforced concrete coating about 1/2-inch thick. The insulated joints prevented considerable long line currents from being generated.

Careful inspection is necessary in the field to prevent metallic contacts between the two aqueducts having dissimilar coatings. During the construction of the Second Hetch Hetchy Aqueduct an accidental short circuit was made in building steel of the San Joaquin Valve House. Because of the high resistivity of soil between the insulated joints at the valve house, the current generated was small in magnitude. On

the bituminous coated pipe 1.94 amperes flowed east from the valve house and 1.13 amperes flowed west from the valve house. Although this current is not great, it will disintegrate the pipe in the course of time.

This westward current is toward the river crossing. If the pipe disintegrated under the river, the cost of repair would run into thousands of dollars. The cost of barges, divers and a clam shell dredger would run several hundred dollars per day.

Carelessness Causes Short Circuits

Sometimes these short circuits are due to carelessness or indifference of the inspectors. Some take the view that just because both aqueducts have a low resistance to ground that they are already short circuited. They base this conclusion on the assumption that because one electrode of a welding machine may be grounded on one aqueduct and the machine used just as effectively on the adjacent aqueduct, that both aqueducts are short circuited. They do not consider the much higher voltage of the welding machine com-

pared to the galvanic potential between the two aqueducts. In short their knowledge of electricity is just enough to get them into trouble when dealing with galvanic corrosion.

In the design of pipe lines the whole job should be tailored to fit the soil survey. Furthermore, interconnections with other pipe lines should not be made when there are any appreciable potential differences between the two. This is particularly true when they have dissimilar coatings. They should be isolated by installing insulating joints in all cross connections.

Acknowledgments

Acknowledgment is made to L. M. Perrin, Senior Electrical Engineer of the San Francisco Public Utilities Commission, for his cooperation in furnishing the electrolysis data on the Hetch Hetchy Aqueducts.

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A Case History Involving Intergranular Failure of Stainless Steel Heater Tubes*

By G. A. WORKS*

General Discussion

THE PHENOL PLANT at the Oleum Refinery of the Union Oil Company of California utilizes a rather well known refining process involving phenol as a solvent for the removal of asphaltic constituents from lube oil stocks.

The unit began operations in 1939 and, insofar as the fired heater was concerned, operated without unusual incident until the annual shutdown in 1949. This heater which provides all the heat required in the process by the circulation of an oil-phenol mixture through one of the separation vessels, was tubed with 4½-inch O.D. carbon steel tubes and fittings in the first four rows of tubes in the preheat or convection bank and with 16-13-3 (AISI Type 316) tubes and fittings in the lower four rows of tubes of the convection bank and the entire radiant section of the heater. This abrupt change in corrosion resistant materials was required because of the increase in corrosive nature of the extract-phenol mixture at the higher temperature and increased velocity caused by partial vaporization.

Table I gives the analysis of a typical tube.

Figure 1 shows the circulating flow.

During the 1949 shutdown a representative number of tubes was inspected and the usual negligible loss of thickness was recorded. The fittings were then headed up and the customary hydrostatic test was applied. However, the pump pressure could not be raised above 50 pounds and it was soon determined that the water was spraying out of numerous cracks in one of the stainless steel tubes. This tube was removed from the heater and replaced with a spare tube and another hydrostatic test was applied. This time two more cracked tubes were discovered. The additional failures were not unexpected but it was clearly time to sit back and take stock of the situation. Fortunately, other revisions were in progress in the refinery which meant that the start up of this unit could be delayed. On the other hand, it was highly desirable, once the unit did start up, to keep it running because high losses of phenol, a relatively expensive material, occur each time operations are interrupted.

The original failed tube was sectioned for metallurgical examination and while awaiting results a closer look was taken at the operating conditions of the heater.

The feed enters at 490 degrees F., is preheated in

Abstract

Failure of a number of Type 316 stainless steel tubes in a fired heater at a phenol solvent treating plant after ten years of service is outlined. Metallurgical investigations showed that carbide precipitation at the grain boundaries had occurred after this length of service at a temperature of about 750 degrees F. thus sensitizing the tubes to intergranular corrosion. Inspection of the remaining tubes in the heater by a Probolog survey and by fluorescent dye penetrant showed that approximately two-thirds of the tubes while in a susceptible state had not yet progressed to the point of developing cracks.

The possibility of salvaging these uncracked tubes for further use was investigated. Samples were heat treated at 1600 degrees F. for 24 hours. Microscopic examination of polished and etched specimens showed a definite agglomeration of the carbides at the grain boundaries tending to break up the network of precipitates. Tensile and bend tests on heat treated and welded specimens showed good results.

This heat treatment was carried out on the uncracked tubes and they were re-installed in the heater. No further difficulty has been encountered after 24 months of service.

the convection tubes to 550 degrees and is further heated to 600 degrees and partially vaporized in the radiant tubes. Tube wall temperatures in the radiant bank are estimated at a maximum of 750 degrees F. It was noted that the tubes that failed, plus one which was discovered later, were in three out of four cases the upper tubes of two tube passes. Figure 2 shows the tube arrangement in the heater.

Sensitization of the austenitic steels to intergranular corrosion normally occurs at temperatures above 900 degrees F. However, it has been reported that prolonged exposure at a lower temperature would result in sensitization and it seemed feasible that this had occurred after 80,000 hours of service at about 750 degrees. With this in mind it was reasonable to postulate that the tubes had failed from intergranular corrosion as a result of carbide precipitation at the grain boundaries and this was borne out by the metallurgical reports which were received somewhat later.

These reports stated that a fine continuous network of chromium carbide had been precipitated at the grain boundaries and that pitting and intergranu-

TABLE I

ELEMENT	%
Cr	16.10
Ni	13.62
Mo	2.95
C	0.11

* A paper presented at a meeting of San Francisco Bay Area Section, National Association of Corrosion Engineers, September 12, 1951.

* Oleum Refinery, Union Oil Company of California, Rodeo, California.

lar cracks originating on both the OD and ID surfaces were found on all specimens. The cracking was largely circumferential in orientation. Figures 3 through 7 illustrate the type of failure. All of these samples were taken from a tube which exhibited numerous cracks; however, the bend specimens shown in Figure 5 are free of cracks which indicates these discontinuities were not prevalent over the entire length of the tube.

A corrosive medium would be required to cause failures to occur once carbide precipitation had taken place. Sulfur-bearing fuels would constitute a source of external corrosion and phenol plus naphthenic acid

in the charge would constitute the source of internal action.

It was obvious that additional tubes in the heater might contain cracks that testing did not reveal; therefore, a critical inspection was required. The Shell Development Company offered its services and a modified Probolog was used to survey the tubes. This was a unique application of the Probolog because it is familiar to most only in the inspection of copper base condenser tubes of small diameter. Because austenitic stainless steels are non-magnetic minor changes in the Probolog circuit and a large diameter probe head permitted its use in inspecting the tubes. The instrument records variations in the magnetic permeability of the material under test and while no advance claims were made it was hoped that cracks, incipient cracks and grain boundary changes might be reflected.

A chart was run on all tubes and the records indicated that two rough classifications might be made; one in which relatively smooth charts were obtained pointing to minor defects, the other in which wide deflections were recorded suggesting cracks or potential cracking. Runs for standardization on a new and a cracked tube aided in the separation. Figure 8 shows typical charts obtained.

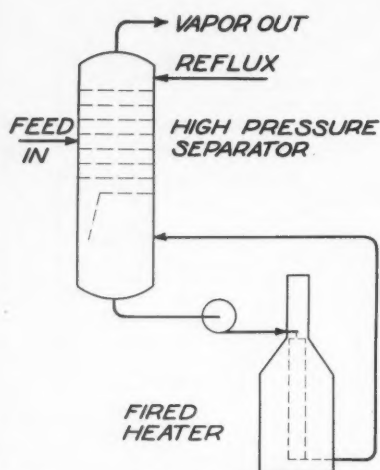


Figure 1—Circulating flow through the fired heater and high pressure separator.

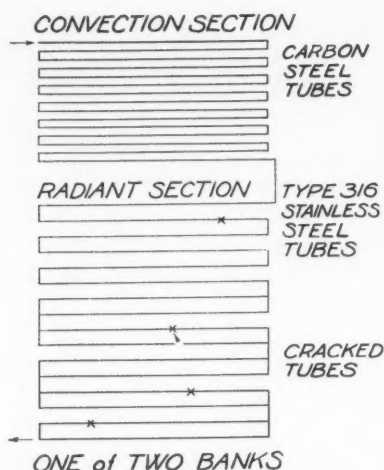


Figure 2—Schematic arrangement of tubes in the heater.

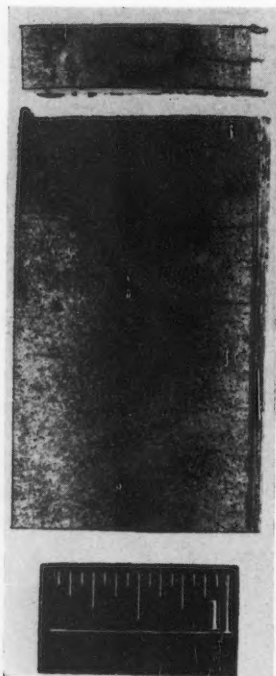


Figure 3—Section of failed tube showing OD cracks penetrating tube wall.

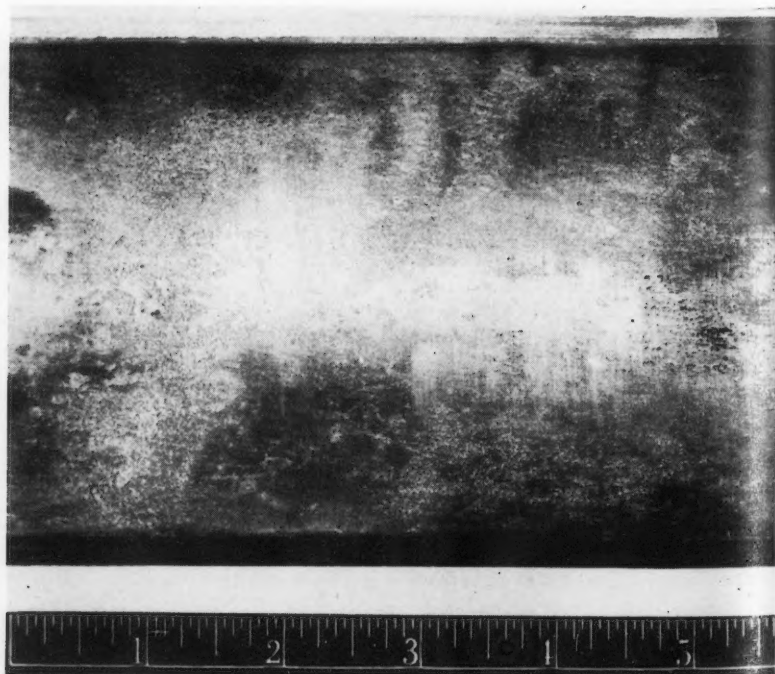


Figure 4—General pitting on pickled ID surface.

The tubes were then inspected by Zyglo in order to bring out cracks that might have been missed in visual inspection. In this method the tubes were painted with the fluorescent oil which penetrates cracks or surface discontinuities. The residual oil was washed from the tubes with water. A developing powder was then blown on the tubes to draw out the penetrant and each tube was examined under near ultra-violet light. Only one additional cracked tube was found and the location of the crack coincided with a wide deflection on the Probolog chart.

Several facts when considered together now indicated that approximately two-thirds of the stainless steel tubes while in a susceptible state had not yet progressed to the point of developing cracks. These were:

1. The grouping of the tubes into a "good" and a "bad" lot by means of the Probolog.
2. The Zyglo survey which showed that only one externally cracked tube remained in the heater.
3. A comparison of the position in the heater of the known cracked tubes with the grouping of the Probolog charts showed a definite pattern for comparison. The cracked tubes as noted previously were the upper tubes of two tube passes. The so-called "bad" tubes as recorded by the Probolog fell mostly into these same positions in other locations in the heater. The "good" tubes lay for the most part in the lower convection bank and the lower tubes of two tube passes in the radiant bank.

If these uncracked tubes could be salvaged for further use a considerable saving could be made over the cost of new replacements. Solution annealing followed by quenching was the first apparent method of accomplishing this. By holding the tubes at a temperature of 2150 degrees F. for perhaps one hour all precipitated chromium carbides at the grain boundaries would be expected to re-dissolve in the matrix. Quenching from this temperature would then fix the alloy in more or less its original state.

There were two reasons for rejecting this plan: First, there was no annealing furnace available in the area that would accommodate the full length of the tubes; and second, the re-precipitation of carbides might occur in a short time.

The suggestion was then made that the tubes could be salvaged by a stabilizing heat treatment in which the tubes would be held at a temperature of around

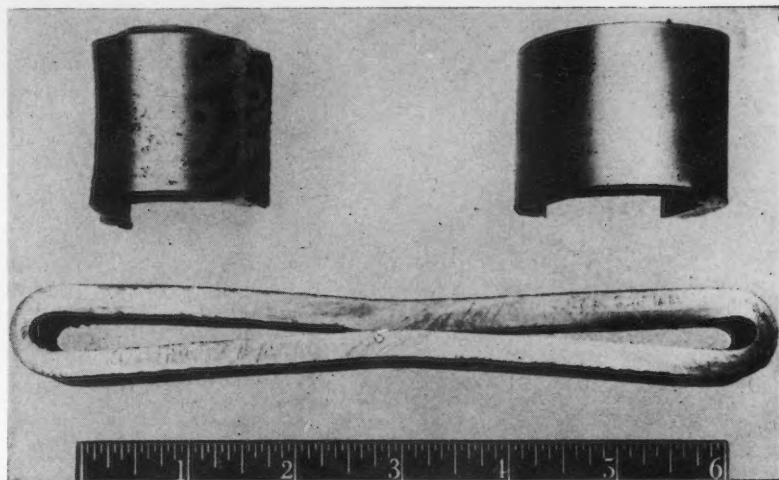


Figure 5—Bending and flattening tests on section of failed tube.

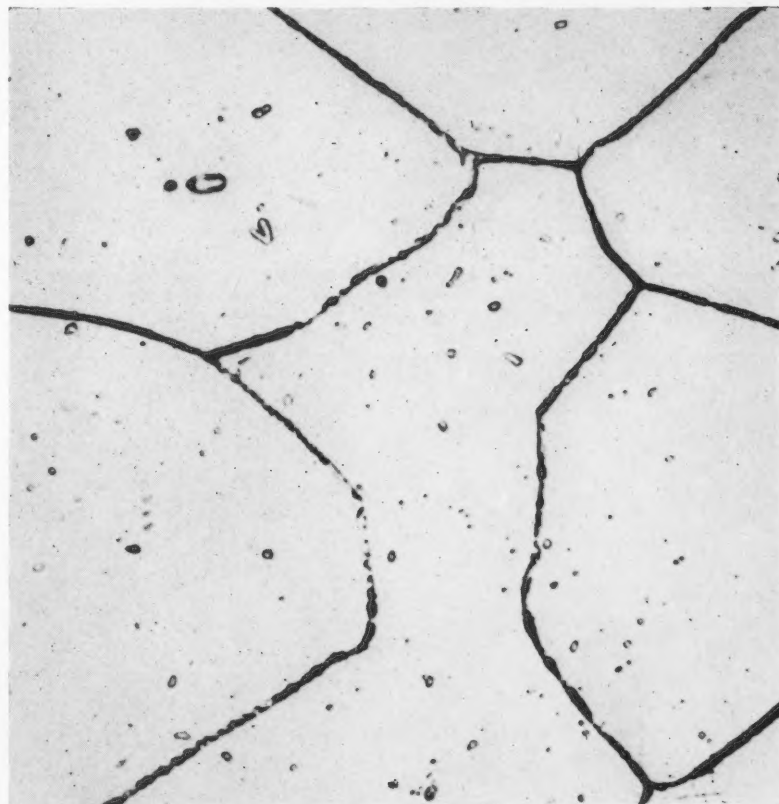


Figure 6—Showing carbides present in chain-like continuity at the grain boundaries. Magnification: 1000x Etch: 10% oxalic acid.

1600 degrees F. for an extended period. This operation is carried out now during manufacture of austenitic stainless steel tubes intended for corrosive service at elevated temperatures. However, this procedure was not followed at the time the tubes in question were made. The purpose of this treatment is to precipitate carbides at the grain boundaries and then cause the carbides to agglomerate or nodulize thus breaking up the continuity of the network. This treat-

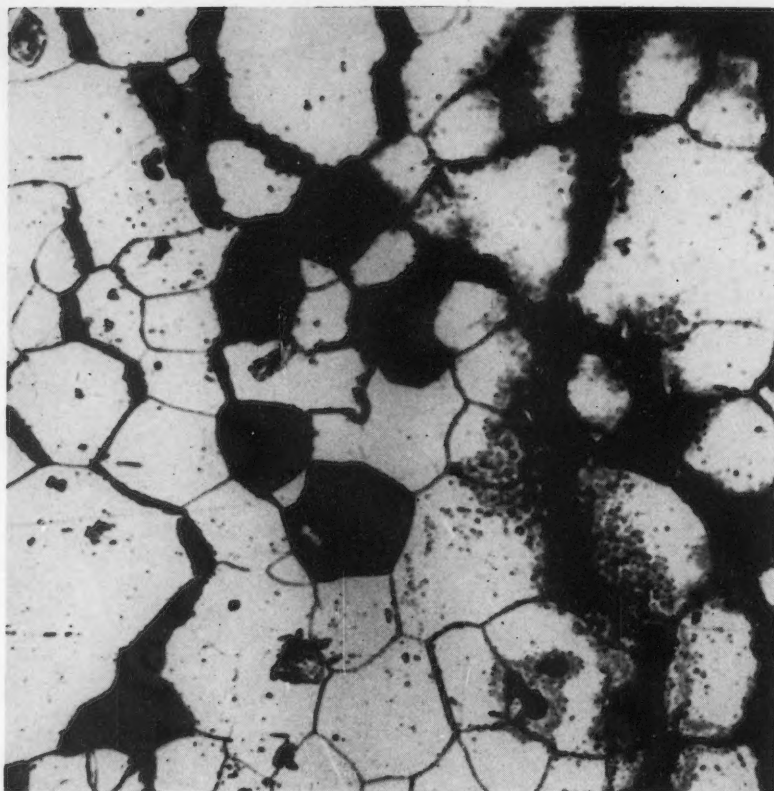


Figure 7—Showing intergranular corrosion cracks at and immediately adjacent to a circumferential fracture visually apparent on the tube surface. Note: Some whole grains have dropped out of this plane surface. Magnification: 100x Etch: 10% oxalic acid.

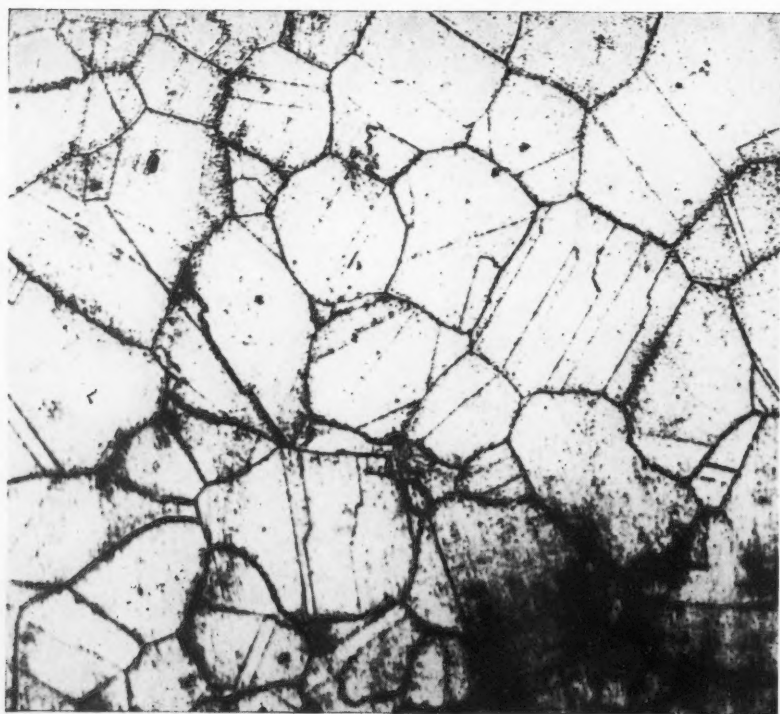


Figure 9—Tube specimen after 1600 degrees F heat treatment. Magnification: 100x Etch: 10% oxalic acid.

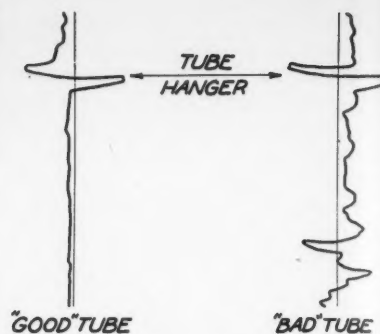


Figure 8—Probolog charts.

ment increases the resistance of the material to intergranular corrosion.¹

One of the tubes in the "good" category was removed from the heater and sections from it were heated to 1600 degrees and this temperature was maintained for 16 hours on one sample and 24 hours on another. Test strips were cut from these sections and subjected to metallurgical examination. Polished and etched specimens at 100 magnifications showed definite agglomeration of the carbides at the grain boundaries resulting in a breakdown of the network continuity. This tendency was more pronounced at 24-hour holding time. Tensile and yield strengths were equal to the specifications for new material of this analysis; however, a reduction in ductility was shown by elongation. Table II gives the results of the physical tests. Specimens that were welded and then given the heat treatment gave similar good results in these as well as flattening and reverse bend tests.

On the basis of these tests it was decided to proceed and thirty-two of the tubes in the "good" classification were removed from the heater. Figure 6 is believed to be representative of the structure of all of these tubes prior to heat treatment. Short stubs were welded on the cut ends to bring the tubes back to their required lengths and then the tubes were heated in a furnace to 1600 degrees. This temperature was maintained for 24 hours. After air cooling each tube was straightened and tested hydrostatically at 1000 pounds per square inch.

These tubes were installed in the radiant banks of the heater.

Sixteen tubes were still required in the lower part of the convection bank. The low corrosion rates ob-

TABLE II—Physical Test Results

	Specimen Welded and Stabilized 24 Hours at 1600 °F.	ASTM A-271-47 Minimum Requirements*
Yield Point, psi.....	40,180	30,000
Ultimate Strength, psi.....	85,120	75,000
Elongation, Percent in 2 Inches.....	38.25	35
Reduction of Area, Percent.....	56.55

* This specification covers Types 304, 321 and 347 but not Type 316.

served on the carbon steel tubes in the upper part of the convection bank led us to predict that carbon steel would be satisfactory in the lower part. However, the return fittings in the lower bank were of stainless steel to match the expansion and corrosion-resistant characteristics of the original tubes. It was known that serious roll leaks would develop if carbon steel tubes were rolled into stainless steel fittings due to the much higher expansion co-efficient of the stainless steel. This difficulty was overcome by welding stainless steel stubs onto each end of the carbon steel tubes thus providing a rolled joint of similar materials.

One may question the advisability of welding these dissimilar materials and then exposing the junction to the temperatures in a fired heater. Undoubtedly, hoop stresses of considerable magnitude are developed; however, it is a fairly common refinery practice

to employ an austenitic rod when stubbing ends on ferritic heater tubes.

The heater was returned to service and has been in operation 24 months at the time of this report. Shutdown inspections were held after ten months and 23 months at which times all of the tubes were measured for corrosion loss and were visually inspected. No irregularities were detected on the stainless steel tubes. A measured corrosion rate of approximately .01 IPY on the tubes in the lower convection bank indicates that the choice of carbon steel here was justified.

Conclusions

The shutdown inspections and the continued uneventful operation of the heater point to success in the treatment performed. These tubes have now served for 24 months after carbide precipitation was detected as a result of ten years of service and yet no failures of the stabilized tubes have been encountered. It is interesting to note that for the past two years the unit has been operating on a naphthenic-base stock which is more corrosive than the stock run previously.

Reference

1. Metals Handbook, American Society for Metals, 1948, p. 551.

NACE Requirements on Acceptance and Publication of Papers

(Quoted from "Guide for the Preparation and Presentation of Papers." National Association of Corrosion Engineers, 1061 M & M Bldg., Houston 2, Texas.)

These instructions and suggestions govern preparation of papers for publication in CORROSION, and for presentation at meetings of the National Association of Corrosion Engineers. Papers may be submitted for consideration without invitation.

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Discussions

The Mechanism of Knife-Line Attack in Welded Type 347 Stainless Steel. By M. L. Holzworth, F. H. Beck and M. G. Fontana. *Corrosion*, Vol. 7, No. 12, 441-449 (1951) Dec.

Discussion by J. J. Heger, United States Steel Co., Pittsburgh, Pa.:

MESSRS. Holzworth, Beck and Fontana demonstrate quite conclusively that the use of a 1200° R. stress relieving temperature for welded Type 347 will cause this material to become susceptible to knife line corrosion. Unfortunately, however, the authors do not indicate the stress relieving temperature that should be used for fabricated and welded articles of Type 347.

Actually, many stainless steel producers and consumers claim that stress relieving of the austenitic stainless steels is not necessary. They argue that these steels are inherently tough and ductile and thus do not require a stress relieving treatment. These arguments are logical and are given further support by the authors' evidence that a stress relief of welded Type 347 at 1200° F. is detrimental to corrosion resistance. However, for many applications, particularly those that involve exposure to environments that would cause stress corrosion cracking, stress relieving of the austenitic stainless steels is a necessary requirement if freedom from stress corrosion cracking is desired.

The authors' data presented in Table II indicate that freedom from knife line corrosion can be expected if the stress relieving temperature is 1650° F. Moreover, Scheil's¹ results published in 1947, indicate that this temperature also relieves a sufficient amount of stresses so that freedom from stress corrosion can be expected. For these reasons, it should be emphasized that only when low stress relieving temperatures are employed does welded Type 347 become susceptible to knife line corrosion. When the stress relieving temperature for adequate time is above 1600° F., stresses are relieved and the danger from knife line corrosion is eliminated.

¹ Welding Journal, Welding Research Supplement, September, 1947, pages 530s-538s.

Reply by M. L. Holzworth, F. H. Beck and M. G. Fontana:

The authors appreciate Mr. Heger's comments regarding knife-line attack in welded Type 347 stainless steel and are grateful for this opportunity to present additional data which it is hoped will answer some of the questions left hanging at the time the paper was written.

The range of stress relieving temperatures in which knife-line attack occurs in welded Type 347 stainless steel was investigated. Steel 1 of Table 1 was selected

for this study. The following table gives the heat treatment and corrosion properties of welded pieces of Steel 1. The corrosive medium was fuming nitric acid at 160° F.

Effect of Heat Treatment on Steel 1

Sample No.	HEAT TREATMENT	CORROSION RATES, MILS PER YEAR (48-Hr. Test Periods)				
		1	2	3	4	5
1	As welded.....	60	330	350	400	400
2	Welded + 1000° F. 2 hrs.	140	160	180	500	500
3	Welded + 1100° F. 2 hrs.	600	1100	disc. knife-line attack		
4	Welded + 1200° F. 2 hrs.	850	680	disc. knife-line attack		
5	Welded + 1300° F. 2 hrs.	860	1000	disc. knife-line attack		
6	Welded + 1400° F. 2 hrs.	350	700	550	700	K.I.A.*
7	Welded + 1500° F. 2 hrs.	280	500	500	500	440

* Knife-Line Attack.

Knife-line attack was most severe in the pieces heat treated at 1100° F., 1200° F., and 1300° F., less severe in the 1400° F. sample and did not occur in the as-welded sample or samples stress-relieved at either 1000° F. or 1500° F. The results of these tests indicate that knife-line attack will not occur in welded sections stress-relieved at temperatures above 1500° F.

In another publication¹ it was mentioned that a stabilizing heat treatment at 1650° F. or 1950° F. on a welded section prior to sensitization at 1200° F. made the pieces immune from knife-line attack. If columbium carbides are dissolved at high temperatures attained during welding, a heat treatment at 1650° F. to 1950° F. should result in the re-precipitation of columbium carbides in the destabilized zone. This should render the piece immune from knife-line attack after sensitization. The following data show that a stabilizing heat treatment at either 1650° F. or 1950° F. prior to sensitization restores the corrosion resistance of the alloy. Steels 1 and 4 of Table 1 were used for this phase of the investigation. Corrosion tests of welded samples were made in 65 percent boiling nitric acid and also fuming nitric acid (FNA).

Effect of Heat Treatment on Steels 1 and 4

Sample No.	Steel	HEAT TREATMENT	Corrosive Media	CORROSION RATES, MPY (48-Hr. Test Period)				
				1	2	3	4	5
1	1	1650° F. ½ hr. + A.....	Huey test	15	20	29	30	35
3	1	1950° F. 24 hrs. + A.....	Huey test	17	19	30	35	40
5	1	1950° F. 24 hrs. + A.....	Huey test	13	18	35	55	65
7	1	1950° F. 24 hrs. + A.....	Huey test	65	17	14	13	20
2	1	1650° F. ½ hr. + A.....	FNA	300	425	420	440	530
4	1	1650° F. 24 hrs. + A.....	FNA	440	680	680	680	600
6	1	1950° F. ½ hr. + A.....	FNA	470	640	600	570	520
8	1	1950° F. 24 hrs. + A.....	FNA	130	280	370	420	420
9	4	1650° F. ½ hr. + A.....	Huey test	19	30	40	40	45
11	4	1650° F. 24 hrs. + A.....	Huey test	29	14	18	19	25
13	4	1950° F. ½ hr. + A.....	Huey test	17	15	22	30	45
15	4	1950° F. 24 hrs. + A.....	Huey test	50	16	16	19	30
10	4	1650° F. ½ hr. + A.....	FNA	190	280	290	280	280
12	4	1650° F. 24 hrs. + A.....	FNA	200	260	280	220	270
14	4	1950° F. ½ hr. + A.....	FNA	200	230	230	260	240
16	4	1950° F. 24 hrs. + A.....	FNA	150	200	200	240	240

A. 1200 degrees, 2 hours.

None of the samples were subject to knife-line attack. This demonstrated the effectiveness of a stabilizing heat treatment in eliminating knife-line attack.

A more detailed study was made on the effect of time at a stabilizing heat treatment (1650° F.). Welded sections of Steel 1 of Table I were held at 1650° F. for ten minutes, one-half hour and two hours. This was followed by sensitization at 1100° F. and 1200° F. for two and 24 hours. The samples were tested in fuming nitric acid at 160° F.

Effect of Stabilizing Time on Steel 1

Sample No.	HEAT TREATMENT	CORROSION RATES, MILS PER YEAR (48-Hr. Test Periods)				
		1	2	3	4	5
1	As welded.....	60	330	350	400	400
2	1650° F. 10 min. + A....	270	440	460	400	400
3	1650° F. 1/2 hr. + A....	210	370	400	360	340
4	1650° F. 2 hrs. + A....	220	420	400	380	330
5	1650° F. 10 min. + B....	1100	1400	1400	discontinued	
6	1650° F. 1/2 hr. + B....	850	1000	1000	discontinued	
7	1650° F. 2 hrs. + B....	700	900	900	discontinued	
8	1650° F. 10 min. + C....	240	330	360	350	310
9	1650° F. 1/2 hr. + C....	230	330	360	360	310
10	1650° F. 2 hrs. + C....	190	350	370	200	360
11	1650° F. 10 min. + D....	220	400	400	230	400
12	1650° F. 1/2 hr. + D....	110	140	140	400	410
13	1650° F. 2 hrs. + D....	110	120	120	400	410

A. 1200 degrees F., 2 hours.

B. 1200 degrees F., 24 hours.

C. 1100 degrees F., 2 hours.

D. 1100 degrees F., 24 hours.

All stabilizing heat treatments followed by sensitization at 1200° F. for two hours gave corrosion rates similar to those obtained for the as-welded sample. However, the corrosion rates for the samples sensitized 24 hours at 1200° F. were much higher. These samples showed a greater rate of attack on the parent metal, less on the weld metal. However, knife-line attack did not occur in any of the samples. Even the short heating time of 10 minutes at 1650° F. was sufficient to precipitate columbium carbides, thus preventing formation of chromium carbides during sensi-

tization. Mahla and Nielsen² have shown that chromium carbides can form in a matter of seconds. It is thus not surprising to find evidence that perhaps columbium carbides form in a very short period of time. In a recent paper Ebling and Scheil³ showed that a stabilizing heat treatment at 1650° F. for two hours before sensitization prevented knife-line attack in Type 347 stainless. Our data indicate that shorter times at stabilizing treatments are as effective as longer times to secure immunity from knife-line attack.

The authors agree with Mr. Heger that in some cases, stress relieving is necessary. This is particularly true when the chloride ion is present in the corrosive medium. A thorough investigation was made to determine the susceptibility of Type 347 steel to stress corrosion in fuming nitric acid. It was shown that Type 347 stainless did not stress crack in fuming nitric acid. Therefore, it is suggested that welded Type 347 stainless steel involving applications in fuming nitric acid should be used in the as-welded condition. If stress relieving is necessary, as in the case of cross-welds, the minimum stress relieving temperature should be 1500° F., preferably higher. If a stress relieving temperature of 1650° F. is used, the re-precipitation of columbium carbides prevents knife-line attack even when the specimen is subsequently sensitized.

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1. M. L. Holzworth, F. H. Beck, M. G. Fontana. Cause and Cure of Knifeline Attack in Columbium Stabilized Steels. *Engineering Experiment Station News*, Ohio State University. p. 20 (1951) Oct.
2. E. M. Mahla, N. A. Nielsen. Carbide Precipitation in Type 304 Stainless Steel—An Electron Microscope Study. *Transactions, Am. Soc. for Metals*, **43**, 290 (1951).
3. H. F. Ebling, M. A. Scheil. Corrosion Data of Welded Low-Carbon Stainless Steel Reprint from *The Welding Journal Research Supplement*, October, 1951.

ERRATA

In the March, 1952 issue, the following errors have been noted:

CONTENTS Page:

Discussion—Literature Survey on Corrosion in Neutral Unagrated Oil Well Brines By F. A. Prange; Reply by Harry R. Copson.....	114a
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(Changing the page number from 111 to 114a)

PAGE FOLLOWING PAGE 114:

Correct the page number at the center of the bottom of the page headed "Discussions" to read:

114a

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Topic of the Month

Corrosion Problems in Ion Exchange Systems

By J. F. WILKES*

THE DESIGN and operation of de-ionizing plants present a challenging array of corrosion problems. Because de-ionization can produce water of extremely low mineral content, often at a fraction of distillation costs, it has won acceptance for high pressure boiler use and in numerous processes requiring mineral-free water. On railroads, Dieselization has stimulated de-ionizer installations to produce high-purity water for Diesel cooling systems and compact trainheating steam generators.

In the de-ionizing process, mineral impurities are removed from water by chemical exchange reactions. In a typical 2-bed plant (Figure 1) water passes through two tanks resembling pressure filters, then through a decarbonator. In the first tank, a strongly acidic exchanger resin removes calcium, magnesium, sodium and other cations, giving up hydrogen (H^+) ions in exchange. Leaving the cation exchanger, the water will contain mineral acidity proportional to the sulfates, chlorides, nitrates and carbonates originally present. In the second exchanger tank, a weakly basic exchange-adsorbent resin extracts the strong mineral acids from the water by direct contact. Carbonic and silicic acids are not removed by weak base anion resins and pass through the bed unchanged. Dissolved carbon dioxide in the anion effluent is removed by aeration in the decarbonator.

Ion exchange reactions are reversible. When their exchange capacity becomes exhausted, the resin beds may be reactivated by contact with regenerant solutions, followed by rinsing. Sulfuric acid at 2%-8% concentration is the usual cation regenerant; 5%-10% hydrochloric acid may be used. Anion exchangers are regenerated with soda ash, caustic soda or ammonia. Both the acid solutions used for cation regeneration and the acid ions released in the cation exchanger contribute to corrosion problems.

Exchanger Tanks—Exchanger tanks normally are protected internally by rubber linings, averaging 3/16-inch thickness. Multiple coats of baked phenolics have been employed, but these coatings are brittle, hence subject to damage in shipment and erection of tanks. For construction of unlined exchanger tanks, Monel, Everdur and stainless steel have been used, but operating experience has been unsatisfactory. In one case, Everdur tanks failed at welds in one year of de-ionizer service. Rubber-lined steel tanks are readily available and less costly than those constructed from special alloys.

Piping, Valves & Fittings—Interconnections require careful consideration.

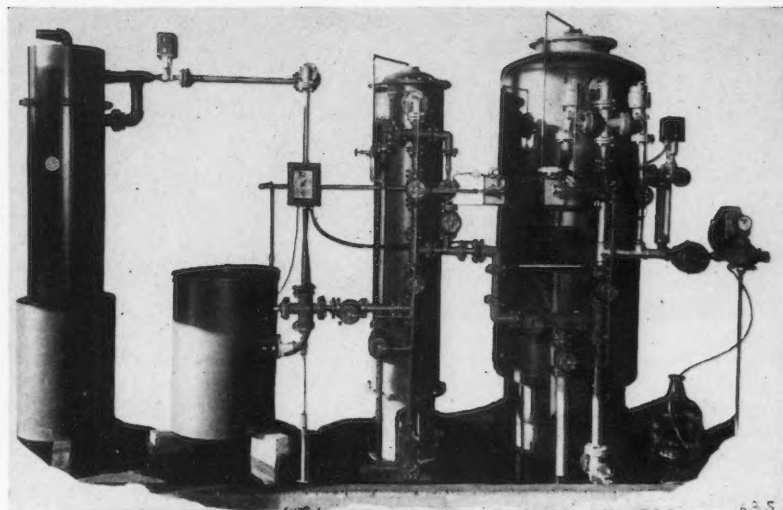


Figure 1—Completely automatic de-ionizer piped throughout with Saran-lined steel. Tanks and valves are rubber lined.

Commonly employed red brass may have only limited service life; accelerated corrosion is experienced when treating water containing appreciable nitrates, plus sulfates and chlorides. Serious damage to weak base anion resins may occur as the by-product of red brass corrosion. When brass outlet distributors and underdrains in cation tanks are corroded by the acid effluent, copper released will combine with the anion exchange resin, tie up active exchange groups and reduce capacity. Copper contamination is difficult to correct, even using acid scrubbing procedures to clean the resin. Copper ions also may catalyze oxidation failures of anion resins.

Stainless steel has been used for interconnections in a few cases. Many de-ionizers have been piped completely with Saran, which has excellent corrosion resistance. However, Saran is brittle in extreme cold, soft when hot, so requires special care in fabrication, shipment and assembly. External support is required for heavy valves and components exerting strain on Saran piping systems. Hard rubber piping is used to a limited extent, generally for interior distributors and underdrains. U. S. Rubber Company's Uscolite has interesting characteristics, may be useful in de-ionizers. It has excellent chemical stability, tensile strength and temperature resistance. Uscolite already is being used for underdrains and distributors.

With plants employing pipe of 2½ inches and larger, rubber lined, flanged pipe and fittings are standard. Rubber lined pipe is not readily available in small sizes and is not suitable for field

fabrication. Recent development of Saran-lined steel pipe and fittings makes it possible to provide complete corrosion protection, even in small pipe sizes. It combines strength of steel with corrosion resistance of Saran and is no more costly than rubber lined pipe. Cleverly designed fittings have been developed for Saran-lined pipe, supplementing existing rubber-lined and Saran-lined valves. Pipe can be obtained pre-cut to specific dimensions, or cut and fitted in the field.

Multi-port Solo-valves, for D-I systems may be protected against corrosive fluids by rubber lining. Everdur castings originally used resisted attack, but often failed mechanically by stress cracking; red brass valve castings now are used. Baked phenolic coatings protect bonnets, ferrous castings contacting corrosive water.

Corrosion of brass solenoid valves controlling plant operation has required redesign. Normally placed in the anion outlet line, they continuously contact high-purity water containing dissolved CO_2 , and occasional traces of mineral acids. Stainless steel replacement of brass pilot valve assemblies helped; however, relocation of solenoid valves in raw water piping ahead of the plant is recommended.

Acid Regenerant System—With D-I systems, the most severe corrosion problems are encountered in cation regenerant systems, which handle sulfuric acid at various temperatures and concentrations. In some acid-handling units, concentrated acid from storage is delivered to a heavy steel measuring tank, then

*Technical Director, Railroad Department, Dearborn Chemical Company, 375 Merchandise Mart Plaza, Chicago 54, Ill.

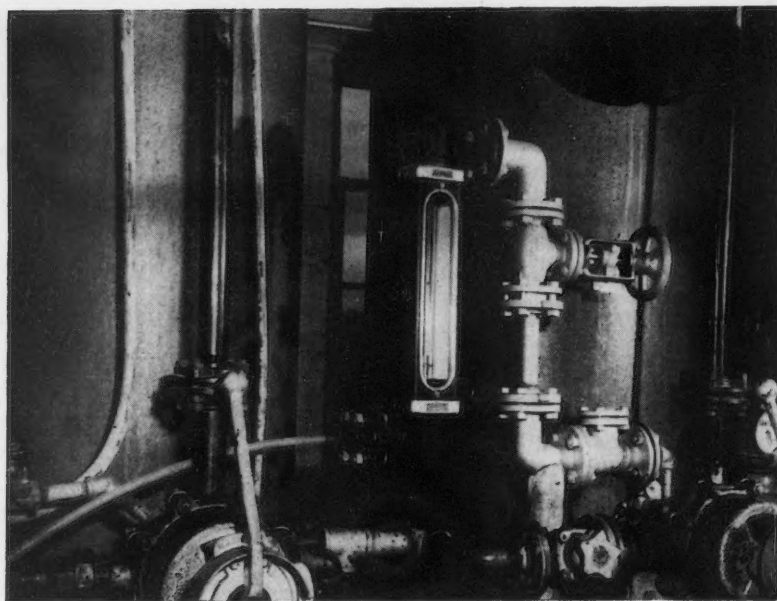


Figure 2—De-ionizer with Saran piping and corrosion-proof acid handling system. Acid valves are Alloy 20. Piping is Saran-lined steel.

drops by gravity to a lead-lined dilution tank. From the tank, an eductor delivers acid to the exchanger tank, with further dilution. For railroad plants, the acid system has been simplified to minimize safety hazards involved in mixing and diluting strong acid. The patented system shown in Figure 2 employs an eductor to draw concentrated acid direct from storage through a Flowrator which indicates feed rate; acid is diluted in the eductor to the desired final concentration. In this system, which eliminates dilution tank and mixer, all pipe and components must be acid-resistant. The unit illustrated employs Saran-lined steel pipe and fittings; metering-shut-off valve and check valve are Stainless 20 (U. S. Pats. 2,134,670; 2,185,987; 2,200,208) with Teflon packing; flanged Flowrator has a Hastelloy C float and Saran tubing through which concentrated acid is drawn from storage. In this case, an Everdur eductor integral with the Solo-valve body is used and has shown surprising corrosion resistance, even though dilution of sulfuric acid from 95% to 2% develops near-boiling temperatures. Duriron external eductors also are being employed for acid handling. In acid systems using screwed fittings, rather than flanged, Stainless 20 pipe and fittings replace Saran-lined steel. Special care is required to insure perfect threads when using this tough alloy. Whenever possible, both Alloy 20 and Saran-lined steel pipe should be cut and threaded on a lathe; an adequate job using hand tools is difficult.

Acid System Valves—Before development of Alloy 20, selection of valves for controlling sulfuric acid posed a difficult

problem. Saunders patent valves—Everdur with rubber or neoprene diaphragms—were tried; diaphragms cracked or decomposed, failing rapidly in contact with concentrated acid. These valves were replaced with iron bar-stock valves which also failed rapidly, particularly in the seats, due to removal of protective deposits by scouring action, when the valves were throttled for rate control. Corrosion also caused failure of iron check valves. Iron valves and swing checks then were modified by siliconizing seats, discs, hinges, and hinge pins. The siliconized checks quickly failed by sticking open, due to sulfation at locations of insufficient clearance, between valve body and working parts. One interesting test valve was brass, fitted with a hand lapped silver disc. This disc corroded at point of contact with the seat, and also in the center of the disc which occasionally encountered dilute acid. Stainless steel bar stock valves and Monel check valves replacing all-iron valves gave inconsistent results, though life was extended when acid systems were thoroughly rinsed after use.

Several field trials were made with brass globe valves modified by replacing fiber discs with Saran or lead. Lead seated valves failed miserably. In contrast, valves with Saran discs served for 12-15 months, when rinsed after use. These valves usually failed by corrosion of threaded stems, rather than seats or discs. In one test, a brass globe valve was fitted with a Saran disc, and an 18-8 stainless throttling pin, to combine functions of rate control and shut-off. This valve is still in service, after three years. Even though modified standard valves occasionally give good service

under careful operation, installation of the more costly system employing corrosion resistant materials throughout can be justified on the basis of safety, reduction of maintenance and long service life.

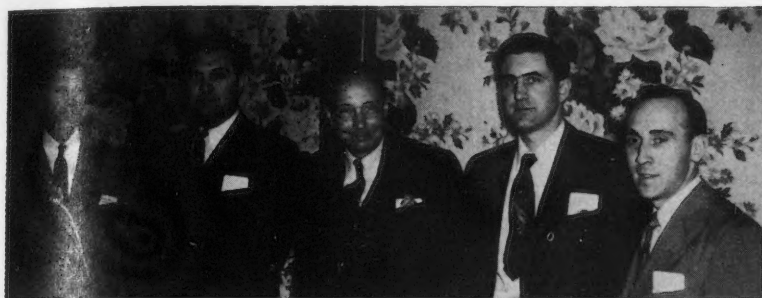
Storage Tanks—De-Ionized water usually is stored in wood, lined or metal tanks. Under emergency conditions, however, storage in concrete basins, or delivery through cement-asbestos pipe may be necessary. Following World War II, several concrete tanks were built for demineralized water storage, due to steel shortage. Substitution of cement-asbestos pipe for steel and cast iron also was required. It was quickly found that both tanks and non-metallic pipe would be dissolved by the high purity water, causing mineral contamination and eventual line failure. Methods to protect concrete and cement-asbestos pipe against aggressive action of pure water were developed. Previous experience with hot-applied wax-type coatings to prevent spalling, cracking of concrete reservoirs suggested similar procedures to protect cement-asbestos pipe. Vinyl coatings also were tested. In the laboratory, coated and uncoated sections of cement-asbestos pipe (Transite) were exposed to de-ionized water having a total mineral content of 7.5 ppm. In contact with uncoated specimens, demineralized water increased 8 ppm in soluble salts after one minute, and averaged 70 ppm increase in 24 hours exposure. In contrast, specimens coated with hot-applied wax-type materials (No-Ox-Ids XX and 6X) caused dissolved solids increase of 1 ppm only after 92 hours exposure. In 92 hours exposure, specimens protected by a black-pigmented vinyl coating (No-Ox-Id 260) increased mineral solids in demineralized water only 0.2 ppm. Based on this laboratory data, a concrete water storage tank for D-I water was coated with No-Ox-Id XX. Because the concrete was coated without proper cleaning, and soon after removal of forms, some loss of coating by peeling was noted after two years service. Cement-asbestos lines protected at the same time, using both wax-type and vinyl coatings, have been in service over four years, with no indication of deterioration.

Experience since the initial applications indicate that concrete protection may be improved by surface preparation prior to coating. After pouring, concrete should age at least 30 days. Surfaces to be coated should be cleaned and etched with acid, followed by thorough rinsing and drying. Although wax-type coatings will adhere well to the cleaned concrete, use of special chlorinated rubber primers ahead of the hot wax coating will increase bond strength and improve resistance to moisture penetration. Surface preparation of concrete also is recommended prior to use of vinyl coatings. The superior penetrating and bonding action of the vinyls, together with ease of application and high chemical resistance, indicate the usefulness of these coatings in protecting concrete or cement-asbestos pipe against attack by aggressive waters.



NACE News

Corrosion in Atomic Plants Discussed at New York



Principal speakers for the joint meeting of the North East Region and Metropolitan New York Section on April 26 are shown here with NACE officials of the Metropolitan New York Section. Left to right are, F. J. LeFebvre, secretary treasurer; T. S. Zajac, chairman, technical practices committee, NACE; H. H. Uhlig, speaker, Massachusetts Institute of Technology; J. E. Draley, speaker, Argonne National Labs., Atomic Energy Commission; K. H. Roll, chairman.

North East Region Hears Predictions on Control of Corrosion

A preview of what the future holds in the corrosion field and an inside picture of corrosion in atomic plants were given to NACE members in papers presented at the joint meeting of the North East Region and Metropolitan New York Section, held in New York City, April 26.

Dr. H. H. Uhlig reported future developments in corrosion prevention in his talk, "Corrosion—A Look into the Future." Among the advances in corrosion mitigation Dr. Uhlig saw were: Application of cathodic protection will be extended to protect metals against stress corrosion and fatigue.

The achievement of pore-free nickel coatings will permit thinner plating. Bright zinc or zinc alloys covered by a clear lacquer will be used as a substitute for nickel. Steel in contact with hydrochloric and sulfuric acids will be coated with nickel-molybdenum (Hastelloy). Titanium will be used as a cladding for steel in hot water tanks to resist pitting and corrosion cracking in chloride-containing waters and on metals exposed to mine and other acid waters.

Sacrificial Metal Use to Expand

Use of sacrificial metals (zinc and aluminum) will continue. Aluminum will be electro-deposited on copper from an organic bath to give resistance to nitric acid. Aluminum coatings on steel will provide resistance against atmosphere containing sulfur compounds.

Wash primers (e.g. polyvinyl butyral) will be used more widely since they save labor by combining surface treatment and priming in one operation. Paints will be improved by adding tetrafluorethylene. Glass lined pipe, cheap and impermeable to oxygen and water will find extensive use. Chromate and nitrate corrosion inhibitors will be improved. An increased degree of purification of aluminum and magnesium will result in a 100-fold increase in corrosion resistance. An alloy composed of aluminum, chromium, molybdenum and iron will supplement the nickel-chromium alloys in the high temperature alloy field.

Atomic Plant Corrosion Problems

Dr. J. E. Draley, the other principal speaker, stated that corrosion so slight it would be ignored in an ordinary commercial plant is cause for major concern when it occurs in an atomic energy plant. Dr. Draley is a corrosion specialist in the Argonne National Laboratory of the Atomic Energy Commission. His address was the first one in which atomic plant corrosion problems had been discussed in public.

In the gaseous diffusion plants at Oak Ridge used for separating uranium iso-

(Continued on Page 4)

TP-16C Heads Shift

R. M. Lawall, American Telephone and Telegraph Co., Cleveland, and W. J. Schreiner, Cincinnati Gas and Electric Co., Cincinnati, have exchanged places as chairman and co-chairman of Technical Practices Committee 16-C on Cathodic Protection of Cable Sheaths. Mr. Lawall is the new chairman.

Wise Elected by TP-9

Election of R. S. Wise to the vice-chairmanship of Technical Practices Committee 9 on Corrosion Inhibitors was announced by Joseph L. Wasco, secretary of the committee's nominating committee. Out of 21 ballots sent to members of TP Committee 9, 19 ballots were returned. Franklin M. Watkins is chairman of the committee.

NOMINATIONS FOR 1953 NACE AWARDS

Should Be Made Not Later Than July 1

The Procedure for the Selection of Persons to Receive the Willis Rodney Whitney and Frank Newman Speller Awards in 1953 as approved by the Board of Directors in Galveston, March 14, 1952, provides for nominations being made by a local section or by an individual member directly to the Chairman of a Region. All nominations should be accompanied by an appropriate statement of the basis of the proposal.

This Procedure requires that prior to July 1, 1952, the Regional Chairman shall forward to the Chairman of the Awards Committee all names proposed for awards, accompanied in each case by summaries of the reasons presented in support of each proposal, but with no indication of the number of duplicate nominations of any individual. The object of this latter provision is to insure that awards will be made on a basis of accomplishments and

other qualifications rather than by any semblance of a popular vote.

The Procedure also requires that the NACE membership be notified of their privileges with regard to nominating candidates for these awards either by direct letter not later than May 1, 1952, or through publication in the May, 1952 issue of CORROSION. A direct letter is not contemplated; hence, this notice as it appears in this issue of CORROSION Magazine will serve as the notification to the NACE membership that nominations for these two awards may be made to their respective Regional Chairman not later than July 1, 1952. Reference to the Regional Division map on page iv and the Directory of Regional and Sectional Officers on pages iv and v of this issue will enable any member to obtain the name and mailing address of the regional chairman to whom his nominations should be sent.

The National Association of Corrosion Engineers now has more than 3200 members.



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Pittsburgh Section Hears Peifer on Stray Currents

Members of the NACE Pittsburgh Section scheduled their last meeting of the season May 8. On the program were an election of officers, discussion of the program for 1952-53, an address, "Corrosion of Underground Structures by Stray Currents," by N. P. Peifer, Corrosion Engineer with the Manufacturers Light and Heat Co., Pittsburgh, Pa. and a gathering at an informal snack bar.

Theodore H. Gilbert

Theodore H. Gilbert, 38, electrolysis engineer for the Southern California Gas Co., died April 22 after a short illness. Mr. Gilbert was active in the NACE, having presented papers on underground pipe line corrosion and related topics before groups of the NACE, the American Institute of Electrical Engineers and the Pacific Coast Gas Association. He was a frequent attendant at NACE annual conferences.

Mr. Gilbert was a graduate of the University of Colorado. After graduating he worked for the San Diego Gas and Electric Co. and U. S. Electrical Motors. In 1940 he entered the employ of the Southern California Gas Co., where in 1942 he began his work with pipe line corrosion problems.

Mr. Gilbert is survived by his widow and one daughter.

Nearly all technical papers presented at annual meetings of NACE are published in Corrosion after review by the Editorial Review Committee of the association.

Corrosion in Atomic—

(Continued from Page 3)

tope 245 from the naturally occurring mixture with U-238, corrosion of the porous barriers in the separation equipment could result in plugging of the pores of the barriers, Dr. Draley stated.

In the plutonium producing plant at Hanford, Wash., heat generated in the atomic pile is removed by water which flows around aluminum cans containing metal uranium slugs. Corrosion of the aluminum would not only reduce the heat transfer properties of the can, but might result in can perforation and consequent contamination of the cooling water by the radio-active fission products.

T. S. Zajac, chairman, technical practices committees, NACE, spoke to members and guests on the activities of the various committees. A sound movie in color, "Corrosion in Action," completed the program.

Liebman and Brown Philadelphia Speakers

Two prominent research engineers, one a recipient of the NACE Whitney award were scheduled to address members and guests of the Philadelphia Section at the May 9 dinner meeting.

A. J. Liebman, in charge of the research department of the Dravo Corp. was listed to speak on "Selection of Surface Preparations and Pretreatments." His subject included the prerequisites of surface preparation work for different environments, the variations that exist among different surface preparation methods and material and how these affect the life and cost of a metal structure.

R. H. Brown, chief of the metallurgical and chemical research laboratory of the Aluminum Company of America was to talk on "Some Controlling Factors in Corrosion." He was to discuss the evaluations to determine the resistance to corrosion of metals from physical and chemical standpoints; laboratory evaluations and their relation to plant performance and factors which control corrosion. He planned to present data and information on how these factors may be determined. Mr. Brown was the recipient of the Whitney award in 1950.

Meeting on June 16 Set by New Orleans-Baton Rouge Section

New Orleans-Baton Rouge Section has scheduled a meeting June 16 at the Architects' and Engineers' club, Hotel DeSoto, New Orleans. Speakers are Warner M. Kelly and Kenneth W. Robbins, both of Otis Pressure Control, Inc., Dallas, who will present a paper on "Corrosion Detection in Oil and Gas Equipment."

Mr. Robbins is engineering consultant in the Otis company's Dallas office, and up to March, 1952, was chief corrosion analysis engineer in the caliper department at Houston. Mr. Kelly, manager of the Otis caliper division was the company's first caliper engineer and has been active in developing the design and operation of the company's caliper. He is a graduate of Oklahoma University.



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Baltimore Gets Data On Newer Plastics

Twenty-eight members and guests of the Baltimore Section heard S. A. Williams of the S. A. Williams Co., Baltimore, Md., speak on some of the newer plastic materials that his company is finding useful in combating corrosion on steel structures. Many new members who joined since the first of the year were present.

Mr. Williams emphasized the importance of proper surface preparation prior to the application of any organic films. He gave cost break-down data on a bridge structure maintained by the Baltimore Transist Co. over a long period. While the initial cost of thorough surface preparation and application of a high quality organic finish system was quite high as compared to annual spotting and repainting, it was demonstrated that the cost when spread over a long period would be reduced by as much as 50 percent. A discussion period followed Mr. Williams' talk.

Internal Corrosion of Pipe Lines Covered By St. Louis Speakers

Election of officers and an address on "Control of Internal Corrosion on Products Pipe Lines" were highlights of the April 15 meeting of the NACE Chicago Section.

Continuous dehydration of products passed through a pipe line results in a gradual "drying up" of the line which reduces internal corrosion to a negligible amount. This observation was among those of J. R. Polston of Standard Oil Company of Indiana at an April 15 meeting of Chicago Section. Mr. Polston and V. M. Kalhauge, also of Standard Oil of Indiana addressed the section on "Control of Internal Corrosion on Petroleum Products Pipe Lines."

Referring to water and oxygen as major factors in corrosion, Mr. Kalhauge indicated through exposition of a typical problem the various sources of water in petroleum products and the magnitude of corrosion resulting. It was shown that inhibitor injection and dehydration both are satisfactory solutions and that each has its merits. Mr. Polston described dehydration by passing petroleum products through towers containing a water adsorbing crystalline compound in which sufficient moisture is removed to prevent condensation at lowest pipe line temperatures.

C. A. Van Natta was elected chairman of the Chicago Section for 1952-53. Other Section officers elected were: L. W. Ewing, Vice Chairman; R. I. Lindberg, secretary; and H. W. Diamond, treasurer.

Gene Kinelski was the master of ceremonies. C. R. Coppersmith and J. F. Sickman of the Aluminum Company of America were hosts for the meeting.

Nearly all technical papers presented at annual meetings of NACE are published in *Corrosion* after review by the Editorial Review Committee of the association.

More than 4190 copies of *Corrosion* magazine are being mailed monthly.

Gamma Irradiation Corrosion, Factors in Corrosion of Steel Surveyed at Birmingham

"Corrosion Effects of Gamma Irradiation," by Clyde Watson, Oak Ridge National Laboratory, Oak Ridge, Tenn., and "External and Internal Factors in the Corrosion of Steels in Air, Soil and Water" by C. P. Larrabee, research and development laboratory of the U. S. Steel Co., Vandergrift, Penna., were papers scheduled for the Southeast Regional Meeting, May 21 in Birmingham, Ala.

In addition to the papers, three films were on the program: Carbon!—Black Treasure; Corrosion in Action, a 70-minute film shown at the NACE Eighth Annual Conference and another tech-

nical film. A fellowship hour, and smorgasbord rounded out the program.

Members of the various Southeast Regional committees for the year were announced. These were: Program Committee: Jack West, chairman, Ivy Parker, Pete Tait, Dave Chadwick. Publicity Committee: Pete Tait, chairman, Everett Griffin. Membership Committee: J. Frank Putnam, chairman, Ramsay Reed, Art Smith and E. D. Vines.

Single copies of most back issues of *Corrosion* are available to NACE members at 50c each and to non-members at 75c each.

News Deadline for

CORROSION

10th of Month Preceding
Month of Publication

NACE Secretaries may obtain on request copies of "NEWS REPORT to CORROSION"

Notices of meetings to be run in advance should be sent in two months before the meeting date. These notices may include as much information as is available at the time including the date, time, place, name of speakers and topics to be discussed. Tentative programs are suitable for publication. Names and addresses of persons to receive registration and fees in advance should be given.

Reports on meetings prepared after the meeting may include all the events, with names and company affiliations of speakers, together with titles and a summary of the speakers' comments. Photographs taken during meetings are welcomed and will be run when they arrive in time for use. Where officers have been elected or changed the specific time at which they assume office should be given.

CORROSION is anxious to cooperate with associations and organizations other than NACE in carrying notices in advance of meetings and reports of meetings when these meetings include events interesting to NACE. The same deadlines as those applying to NACE communications apply to notices from other organizations.

The NACE always welcomes receipt of comments or discussions of its technical material. Persons who wish to discuss constructively technical material in *CORROSION* are invited to submit three copies to: Central Office, National Association of Corrosion Engineers, 1061 M & M Building, Houston 2, Texas.



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Southwestern Ohio Nominations Made

The nominating committee for Southwestern Ohio Section presented a slate of candidates for letter balloting at the April 29 meeting as follows:

For chairman, Roy O. McDuffie; for vice-chairman, Arthur D. Caster, Arthur G. Fasold; for secretary, Lewis M. Lederer, E. F. Neuzel; for treasurer, R. L. Wood, Sylvan Falck; for directors (four to be elected): R. B. Stevenson, Alfred D. Jess, Robert J. Paul and Robert F. Romell.

Arthur D. Caster, Waste Disposal engineer for the city of Cincinnati gave an illustrated talk on industrial waste treatment. There were 14 members and nine guests at the dinner meeting.

Whitney Named Chicago Conference Co-Chairman

F. L. Whitney, Jr., St. Louis, Mo., has been named co-chairman of the Technical Program for the Ninth Annual NACE National Conference and Exhibition to be held in Chicago, Ill., March 16-20, 1953. Mr. Whitney is with the Monsanto Chemical Co., St. Louis.

chromates are working on the railroad



IN the modern diesel locomotives, as well as the sleek streamlined passenger trains, chromium chemicals play an important role.

Millions of pounds of chromates and bichromates will be used this year as corrosion inhibitors in diesel cooling systems. This protection is essential for continued operation of the railroads. In other parts of the locomotive, hard chromium plating

increases the life of cylinder liners and bearing surfaces, thereby contributing to the greatly increased mileage which a diesel locomotive can operate without shop service.

Passenger equipment today makes frequent use of chromium plating for tarnish-free decoration and resistance to wear, while in air conditioning equipment chromates again are the most effective corrosion inhibitors.

In maintenance of the right of way, chromates are used for preserving wooden poles, cross arms, bridges, platforms and railings, furnishing protection against rot and termites, while providing a surface which is clean and may be painted. Freight cars also have a longer life due to the value of chromates as wood preservatives.

Still other applications, which are under study and test, indicate that the railroads, like many other important industries, are finding in chromium chemicals a new source of economies in operation and maintenance.

Write to our Research and Development Department for further information regarding chromium chemicals.

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Glass-Lined Equipment, Metallizing Discussed At St. Louis Meeting

"Glass-Lined Equipment" was the subject of a talk by S. W. McCann, factory manager of the Pfaunder Co., Rochester, N. Y., to a joint meeting of the Greater St. Louis Section of the NACE and the American Institute of Chemical Engineers.

Mr. McCann gave a brief history of glass-lined equipment and the types of equipment now available to industry, including a survey of the chemical, pharmaceutical, dairy and food industries. He also discussed the physical and chemical properties of the glasses used as linings. Color slides were used to illustrate the various steps in the production and processing of glass-lined equipment. A discussion period followed the talk.

Members and guests of the NACE Greater St. Louis Section, meeting March 17, heard an address on "Recent Developments in Metallizing," by W. B. Meyer of the Nooter Corp., St. Louis, Mo.

Mr. Meyer gave a general description of methods of metallizing and commented on some of the new developments in the field. He showed a number of slides illustrating various applications of the process.

Fungi to Be Studied

How fungi strains can build up resistance to wood preservatives will be investigated by holders of a fellowship at the University of Pittsburgh. Koppers Co., Inc., will support the fellowship to the extent of \$5000 for one year.

High and Low Pressure Oil Well Corrosion Is Discussed at Houston

"The Studies of High and Low Pressure Sweet Oil Well Corrosion" by H. L. Bilhartz was the scheduled talk for the Houston Section meeting, May 14. Mr. Bilhartz is with the chemical engineering section of the Atlantic Refining Co., Dallas, Texas. He is chairman of Technical Practices Committee 1, Corrosion of Oil and Gas Well Equipment.

R. C. Buchan of the chemical engineering section of Humble Oil and Refining Co., Houston, Tex. was selected to lead the floor discussion following the main address.

It was planned to distribute prepared charts relating to the correlated studies of well corrosion and to set up a display of corrosion specimens. Arrangements were made for a fellowship hour and dinner to precede the meeting.

Aluminum Is Verink's Topic at Corpus Christi

"Use of Aluminum in the Oil and Petrochemical Industry," was the topic of Ellis D. Verink before 16 members and 11 guests of Corpus Christi Section at its April 30 dinner meeting. Mr. Verink, with Aluminum Company of America, New Kensington, Pa., illustrated his talk with slides.

At a short business meeting committee members were named for the year including a new committee, the Educational Committee.

Measurements Used In Cathodic Systems Reviewed by Howell

Measurements that enter into the design and verification of results of cathodic protection installations were discussed at the April 16 meeting of San Francisco Bay Area Section at San Francisco. R. P. Howell of Standard Oil Company of California emphasized soil resistivity surveys as practical in determining where cathodic protection is needed. Potential surveys, he said, are accepted generally as being good criteria of protection. A simple method of determining current densities on protected lines using soil resistivity and potential data was outlined.

There were 41 members and guests present.

Student Paper Award To Be Given by NACE

An award will be established by the National Association of Corrosion Engineers for the best paper published in Corrosion magazine by a young author. The NACE board of directors has approved acceptance of the award to be made by an anonymous donor.

While the title of the award has not been set, nor are the criteria for selecting the paper determined, it is hoped the award may be made for the first time to the author of a paper published in 1952.

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Many Papers at ASTM June 23-27 Meeting Have Corrosion Interest

Following are some of the titles of technical material of corrosion interest to be presented at the June 23-27 meeting of American Society for Testing Materials at New York:

Effects of Notches and Metallurgical Changes on Strength and Ductility of Metals at Elevated Temperatures

(Sponsored by Joint Committee on Effect of Temperature on the Properties of Metals)

A Survey of Embrittlement and Notch Sensitivity of Heat Resisting Steels—George Sachs, Horizons Inc. and W. F. Brown, Jr., Lewis Flight Propulsion Lab., NACA.

The Effect of Grain Size and Test Temperature on the Fatigue Properties of a Precision-Cast Co-Cr-Ni-W Alloy—P. R. Toolin, Westinghouse Electric Corp.

Behavior of Stainless Steels at Elevated Temperatures—A. B. Wilder and E. F. Ketterer, National Tube Co.

Continuous Analysis of Industrial Water and Industrial Waste Water

(Sponsored by Committee D-19 on Industrial Water)

Some Practical Aspects of the Measurement of pH, Electrical Conductivity and Oxidation-Reduction Potential of Industrial Water—Robert Rosenthal, Industrial Instruments, Inc.

Continuous Measurement of Dissolved Gases in Industrial Water—J. K. Rummel, of Sheppard T. Powell.

Conditioning and Weathering

(Sponsored by Committee E-1 on Methods of Testing)

Outdoor Exposure Testing on Racks and Fences—K. G. Compton, Bell Telephone Labs., Inc.

Organic Coatings—E. J. Dunn, Jr., Brooklyn 1, N. Y.

Fundamentals of Atmospheric Elements—B. C. Haynes, United States Weather Bureau.

Adhesives and Organic Plastics—Frank Reinhart, National Bureau of Standards, and Lucius Gilman, Picatinny Arsenal.

Metallic Coatings—C. H. Sample, International Nickel Co.

Accelerated Weathering Devices—R. H. Sawyer, Devoe & Reynolds Co.

Paint

ASTM Committee D-1 on Paint, Varnish, Lacquer, and Related Products. Paint, Varnish, Lacquer and Related Products, C. H. Rose, National Lead Co., and E. W. Boughton R. T. Vanderbilt Co., Inc.

Drying Oils, Francis Scofield, National Paint, Varnish & Lacquer Assn., Inc. Bituminous Emulsions, R. H. Cubberley, The Flintkote Co.

Volatile Solvents for Organic Protective Coatings, M. B. Chittick, American Mineral Spirits Co.

Accelerated Tests for Protective Coatings, R. H. Sawyer, Devoe & Reynolds Co., Inc.

Methods of Chemical Analysis, Paint, C. Y. Hopkins, National Research Council of Canada.

Varnish, J. C. Weaver, The Sherwin-Williams Co.

Optical Properties, W. C. Granville, Container Corp. of America

Resins, R. W. Stafford, American Cyanamid Co., and C. F. Pickett, U. S. Dept. of the Army

Specifications for Pigments (Dry and in Oil), C. L. Crockett, Norfolk & Western Railway Co.

Physical Properties of Materials, M. R. Euverard, Interchemical Corp.

Cellulosic Coatings, Related Materials, F. H. Lang, The Sherwin-Williams Co.

Painting of Metals, A. J. Eickhoff, National Lead Co.

Fretting Corrosion

(Sponsored by Committee D-2 on Petroleum Products and Lubricants, Technical Committee G)

The Present Status of the Problem of Fretting Wear—W. E. Campbell, Bell Telephone Laboratories, Inc.

Introductory Remarks for Symposium on Fretting Corrosion and Description of NACA Research on Fretting—Douglas Godfrey, National Advisory Committee on Aeronautics

Effect of Lubricants in Minimizing Fretting Corrosion—E. W. Herbek and R. F. Strohecker, The Texas Co.

Plastics

(Sponsored by Committee D-20 on Plastics)

Controlled Laboratory Exposure—L. Boor, Philadelphia Quartermaster Depot, U. S. Army

Measurement of the Effect of Temperature on Some Physical Properties of Plastics—E. B. Cooper, E. I. du Pont de Nemours & Co.

Dutch Aluminum Report

Use of aluminum as a building material is described in "Aluminum Als Bouwmateriaal," an illustrated booklet by J. W. Boon and W. G. R. de Jager. The booklet containing 32 pages of text and illustrations is a publication of Corrosie-Instituut T. N. O. It is in Dutch and costs 5.50 francs.



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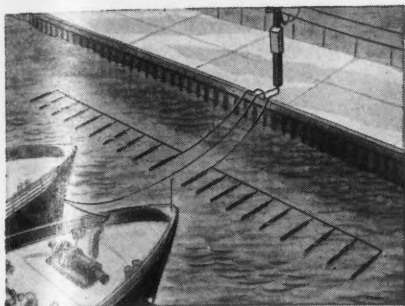
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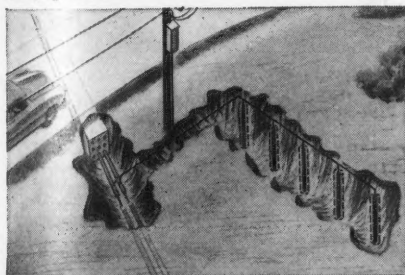
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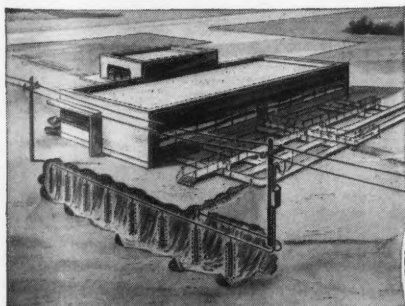
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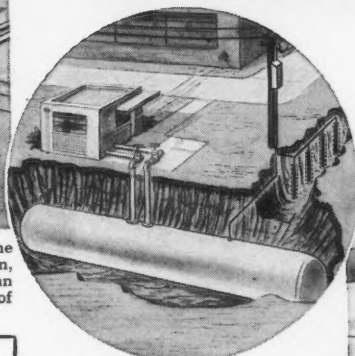
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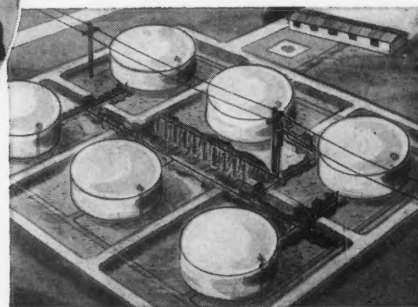
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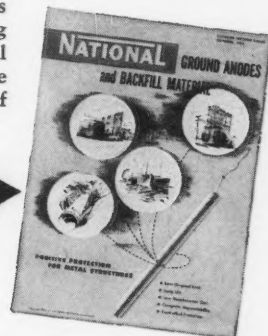
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AIChE Hears Papers Related to Corrosion

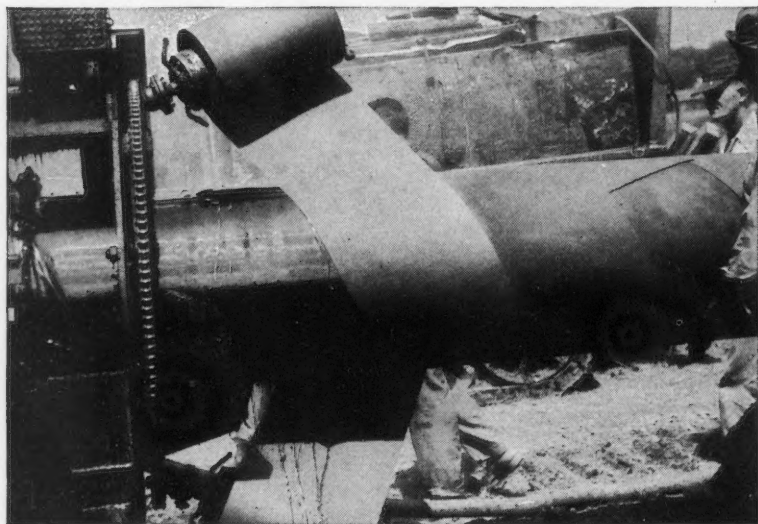
The American Institute of Chemical Engineers 1952 national meeting was scheduled to be held at French Lick, Ind., May 11-14.

Among the 17 papers scheduled for the program were: "High Vacuum Technique—The Incurred Savings When Applied to Concentration," by E. J. Kelly, Carrier Corp. Mr. Kelly's paper dealt with the application and adaptability of high vacuum as applied to the concentration of chemicals. One of the economic aspects of the high vacuum technique was the cost of corrosion and the influence on the attendant maintenance.

Another economic factor was the allowable use of materials not presently used because of the susceptibility to corrosion in many conventional processes.

"Corrosion Problems in Steam Jet Vacuum Equipment," by David H. Jackson, Croll-Reynolds Co., Inc., dealt with the accelerated corrosive action of most vapors due to high velocities up to 4000 ft. per sec. Extent of corrosion, erosion and effects of sudden temperature changes, quick changes from moist to superheated steams, all were discussed. The paper gave industrial operating results on a wide variety of corrosion resisting materials including special alloys, plastics and carbon.

In 1952 over 52,000 copies of reprints of material from CORROSION were printed.



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ASPHALT AND ASBESTOS BUILDING MATERIALS

Corrosion Problems

E. A. TICE, Editor

Corrosion Engineering Section, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Submit questions and answers for this column in duplicate to the editor. All questions become property of NACE. Questions and Answers may or may not be published under this heading, and may at discretion, be answered by mail directly. Answers to questions are solicited. Authors of questions will remain anonymous to readers while authors of answers may remain anonymous if they request it.

Editor's Note—Re answer to Question No. 77 dealing with the flame spraying of Teflon coatings, in the April issue, a typographical error was made. It was stated that spark tested coatings $\frac{7}{8}$ mils thick applied to steel test coupons have shown exceptional liquid phase corrosion resistance. This should have referred to coatings 7 to 8 mils thick.

QUESTION

No. 20—What is the best type of paint for chemical laboratory interiors? (Editor's note—In the April issue one contributor stated that chlorinated rubber base paint had given good service in his laboratory. Another suggestion is presented this month, as follows.)

ANSWER

In general, the service conditions in the average chemical laboratory are not severe and in our experience have been met by pure alkyl finishes. This, of course, is particularly true in whites, where the low degree of film yellowing of an alkyl is desirable.

Another material has been used for some time and gives good results even under very adverse conditions. This material based upon a synthetic elastomer contains very small degrees of obnoxious solvents. The obnoxious solvents referred to in the previous answer are aromatic in nature and are necessary for dissolving chlorinated rubber. The synthetic elastomer referred to uses only a very small portion of aromatic solvents and as a consequence, has a low odor level. It has been successfully used in bakeries, dairies, and breweries without questions about its odor.—Martin E. Schleicher, Technical Director, McDougall-Butler Co., Inc., Buffalo, N. Y.

QUESTION

No. 41—Has there been found an effective solution to the problem of under-film corrosion, sometimes referred to as "worm tracking" under organic coatings such as lacquers and varnishes, applied on sheet steel or tin plate?

ANSWER

It is the understanding that Bonderizing plain steel prior to painting will reduce the incidence of underfilm or "worm tracking" type of corrosion that sometimes occurs under organic finishes. Possibly a Bonderized galvanized or a Bonderized zinc flash plated sheet would be still better than the plain steel Bonderized.—Arba Thomas, Armco Steel Corp., Middletown, Ohio.

(Continued on Page 12)

ANOTHER **ERKOTE** APPLICATION OF MASTIC COATING



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Corrosion Problems—

(Continued from Page 10)

QUESTION

No. 94—(From one of our French Associates) This problem is in reference to petroleum refining. Gasoline vapors, after leaving the top of distillation towers, generally receive an ammonia injection to neutralize the free hydrochloric acid resulting from hydrolysis of $MgCl_2$ and $CaCl_2$ contained in the crude. This ammonia gas injection is generally regulated so that the water pH, after condensing mixed gasoline and water is as close to 7 as possible.

In spite of this injection, we have observed that in the temperature range

of 100 degrees C or somewhat higher, high corrosion rates for steel equipment prevail. Similarly, gasolines already neutralized with ammonia and insufficiently decanted after condensing, do sometimes, when reheated for rerunning show again the same corrosive properties in the above mentioned temperature range.

We should like to know whether other refineries using ammonia as a neutralizing agent have observed the same effect and whether any research has been conducted to determine the efficiency of this process at various temperatures. Literature references connected with this problem would be most welcome.

ANSWER

Considerable information has been published on this subject, and you might find the information contained in the following references to be useful in connection with the solution of your problem:

1. Neutralization as a Means of Controlling Corrosion of Refinery Equipment by E. Q. Camp and Cecil Phillips — Corrosion Magazine, February 1950, Volume 6, No. 2.
2. Corrosion Prevention in Processing Sour Crudes by E. Q. Camp—Corrosion Magazine, August 1948, Volume 4, No. 8.
3. Crude Still Overhead System Corrosion by A. F. Blumer—Corrosion Magazine, May 1949, Volume 5, No. 5.
4. Low Temperature Corrosion in a Crude Distillation Tower by T. N. Griswold—Oil & Gas Journal, March 17, 1952.

In spite of efforts made to desalt crudes and to inject ammonia into the reflux line at the top of distillation columns, experience has shown that steel is not an altogether satisfactory material because of the difficulty in maintaining a neutral pH.

Monel is being widely used in this country for lining the top sections of these columns, as well as for the internals such as bubble caps, trays, holddown bars, etc., because it is more inherently resistant to corrosion by the fluctuating acid or alkaline conditions that may be encountered. Even with the use of Monel, the practice is to inject ammonia and in some cases it has been found necessary to introduce it directly into the tower at a point perhaps 4 or 5 trays down from the top, as well as into the reflux. — J. F. Mason, Jr., International Nickel Co., New York, N. Y.

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F. Guy White, technical director of Granite City Steel Company received the 1952 annual award of the Galvanizers Committee for distinguished service to the committee and to the galvanizing industry.



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BOOK REVIEWS

Selected Values of Chemical Thermodynamic Properties. By Frederick D. Rossini, Donald D. Wagman, William H. Evans, Samuel Levine and Irving Jaffe. National Bureau of Standards Circular 500, buckram bound, 1268 pages. Government Printing Office, Washington 25, D. C. . . . \$7.25.

This volume contains values of the heat and free energy of formation, entropy, heat capacity and heats and temperatures of transition, fusion, and vaporization for all inorganic compounds and organic compounds (containing not more than two carbon atoms), where such data are available. Separate tables give references to the original literature from

which the values were derived. The introduction discusses units of energy and fundamental constants, definition of symbols, abbreviations and conventions regarding physical states, standard states, internal consistency and order of arrangement of the chemical substances. An index to the tables is appended.

Resulting from a project for maintenance of tables of thermochemical and chemical thermodynamic data, this circular contains all the loose-leaf tables of Series I and II of *Selected Values of Chemical Thermodynamic Properties* issued by NBS from March 31, 1947, to March 31, 1950. The tables of references to the literature were not previously issued. Additional loose-leaf material to supplement data in the circular and also to give high temperature thermodynamic

properties of chemical substances, being prepared under the direction of Donald D. Wagman, will be sent without charge to research, educational and industrial laboratories upon request.

This NBS work is being conducted in part under the sponsorship of the Office of Naval Research, Department of the Navy.

Tables of Chemical Kinetics, Homogeneous Reactions. National Bureau of Standards Circular 510, xxiv, 731 pages. Government Printing Office, Washington 25, D. C. . . . \$4.00.

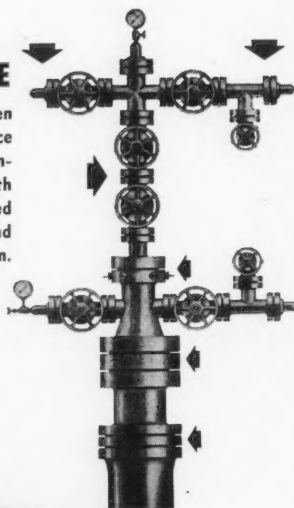
This circular presents a critically evaluated compilation of the available numerical data on rates and rate constants of homogeneous chemical reactions. Stress is laid throughout on experimentally ascertained facts, and data depending on interpretations are generally not included.

Supplementary tables give additional useful numerical information. References are usually provided for secondary effects, in particular the great variety of

(Continued on Page 16)

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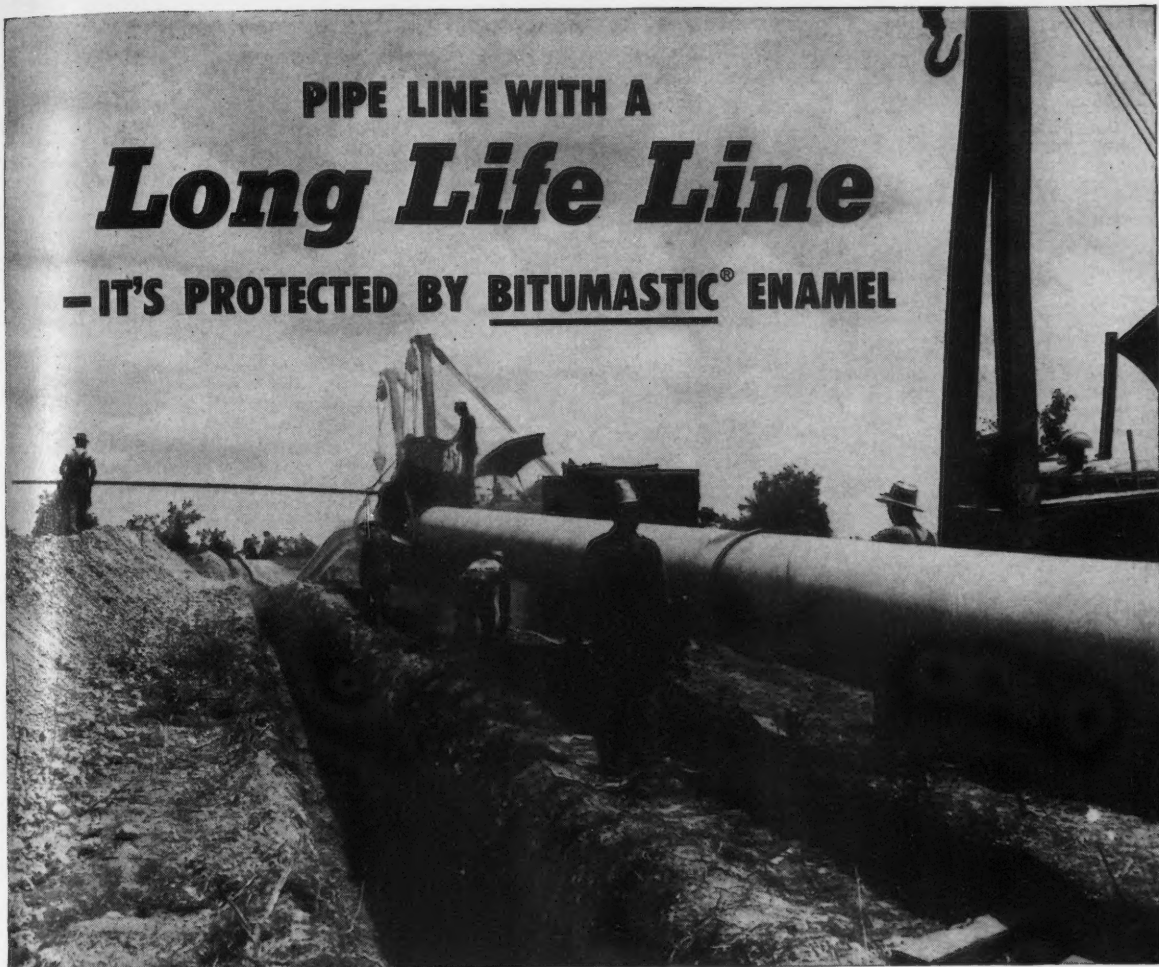
CORROSION LABORATORY HEAD

Chemist, or engineer, with academic training in corrosion fundamentals is wanted to head semi-works corrosion laboratory. Other essential qualifications: (1) several years of industrial experience in this field; (2) personality and temperament to deal with co-workers at all levels. Work involves evaluation of materials of construction, the screening of new chemicals used as corrosion inhibitors, and also may include some traveling for technical counselling of customers. Reply, which will be kept confidential, should be in writing and include complete resume of education and experience.

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Film Rupture Mechanism of Stress Corrosion*

STRESS-CORROSION cracking, caused by the combined action of stress and corrosion, can be responsible for the spontaneous service failure of objects ranging from brass cartridge cases to stainless-steel coffee urns. Although the problem is an important one, much remains to be learned about the mechanism of stress-corrosion cracking. A continuing investigation at the National Bureau of Standards, conducted by Hugh L. Logan of the NBS corrosion section, now provides new data on some of the mechanical and electrochemical phenomena involved.¹

Corrosion is generally considered to be an electrochemical phenomenon, involving the flow of minute electrical currents between areas of different potential. When most metals are exposed to ordinary atmospheres, a thin oxide film is quickly formed that tends to protect the metal from further corrosion. According to the most generally accepted theory,² which the NBS study tends to confirm, stress-corrosion cracking starts with a scratch or break in this protective film. When the protective film is broken through, the freshly exposed metal is more anodic (more negative) than the surrounding film-covered surface, and if moisture is present an electric current flows that causes the metal to be removed from the exposed area.

According to Mears, Brown and Dix, "if attack penetrates preferentially along a narrow path, it would appear axiomatic that a component of tensile stress normal to the path would create a stress concentration at the base of the localized corroded path. The deeper the attack and the smaller the radius at the base of the path, the greater would be the stress concentrations. Such a condition would act to pull the metal apart along these more or less continuous localized paths. At sufficient concentration of stress, the metal might start to tear apart by mechanical action . . . the tearing action described above would expose fresh metal, unprotected by films, to the action of the corrosion environment. Because this freshly exposed metal is more anodic, an increase in current flow from the base of the localized path to the unaffected surface

would be expected, and hence there would be an acceleration of corrosion. Further corrosion would result in further tearing of the metal, and as a result increased rate of penetration would occur because of the mutual effect of the corrosion environment and the tensile stress."²

To get a better understanding of the forces at work in stress corrosion, the NBS investigators measured electrochemical potentials of five alloys in normal film-covered and film-free conditions, both stressed and unstressed (see Table I). Specimens were immersed in a suitable electrolyte and potentials were determined using a calomel reference electrode of the saturated KCl type.

Studied were an aluminum alloy, a magnesium alloy, two brasses, a low-carbon steel and a stainless steel. Potentials were measured first for unstressed specimens having normal thin oxide films resulting from ordinary atmospheric exposure. Potentials were then measured for the same specimens after the filmed surfaces had been removed by abrasion with metallographic polishing paper. The abrading was done in an inert-gas (argon) atmosphere in a dry box, and the potentials were measured without removing the abraded

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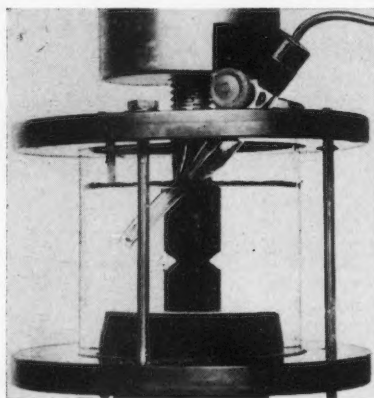


Figure 1—In a recent study of stress corrosion by the National Bureau of Standards, metal specimens were abraded in an inert (argon) atmosphere to remove the air-formed film that is ordinarily present. Using the equipment shown, the operator works through rubber gloves to abrade specimens inside the argon-filled-and-sealed enclosure. Electrochemical solution potentials of the film-free specimens are then measured without removing the specimens from the air-free enclosure. Photo 20929-649.



Figure 2—To measure the change of electrochemical solution potential with stress in the NBS investigation, a notched metal specimen (center) was placed in a suitable cell filled with an electrolyte (usually potassium chloride). The potential between the specimen and an immersed electrode (entering the solution at an angle) was measured as a tensile stress was applied to the specimen. The specimens were coated with non-conducting waterproof lacquer, a thin strip of which was removed at the base of the notch to expose a small maximum-stress area of metal. Photo 520200-649.

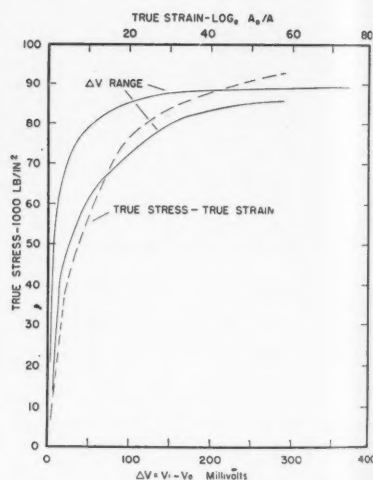


Figure 3—Change of potential with stress (solid lines) and true stress-true strain relations (dotted line) for 61% Cu, 36% Zn, 3% Pb brass, as found in the NBS stress-corrosion study. Photo 510425-649.

*Summary of a technical report by National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.

BOOK REVIEWS

(Continued from Page 14)

salt effects, etc. In addition, the circular contains a list of references to literature in the field and some concise comments on a variety of additional items of information, both on the table as a whole and on particular reactions.

The tables presented in the present volume are a cooperative effort sponsored by the National Bureau of Standards, the Committee on Table of Constants of the National Research Council, and Princeton University. These and other scientific organizations are working together to compile separate critical tables of data in selected fields in which the need is apparent and there are available experts thoroughly familiar with the subjects to undertake the work.

TABLE I
Electrochemical Solution Potentials,¹ and Maximum Change in Potential with Stress, for Several Alloys

ALLOY	Electrolyte	ELECTROCHEMICAL SOLUTION POTENTIALS UNSTRESSED SPECIMENS		Maximum Change in Potential With Stress Volts
		Normal Film Volts	Film-Free Volts	
24S-T4 Aluminum Alloy	KCl (saturated)	—0.67	—1.43	0.610
70% Cu—30% Zn Brass	5% NH ₄ OH + 5% (NH ₄) ₂ CO ₃	— .47	—0.96	.700
61% Cu—36% Zn—3% Pb Brass	5% NH ₄ OH + 5% (NH ₄) ₂ CO ₃	— .39	— .98	.510
AZ31 magnesium alloy	3.5% NaCl + 2% K ₂ CrO ₄	—1.51	—1.645	.240
Low carbon steel	5% NH ₄ NO ₃	—0.60	—0.72	.160
Type 302 stainless steel	KCl (saturated)	— .28	— .78	.315

¹ With respect to calomel reference electrode of saturated KCl type.

Film Rupture—

(Continued from Page 16)

specimen from this atmosphere. Each metal studied was more cathodic (more positive) in the normal film-coated form than in the abraded form, by amounts ranging from approximately 0.12 volt to 0.76 volt.

The electrochemical solution potentials of the same alloys, in the normal film-covered conditions, were then measured with stress applied. It was postulated that, when tension is initially applied to a metal, small breaks develop in the protective film, giving corrosion a chance to get started before a fresh film can form. If the electrochemical potential of the unprotected area alone could be measured, it would presumably be roughly the same as that of a film-free surface. Measurement of change of potential with stress has been attempted before, but the attempts have generally been unsuccessful. The difficulty of measurement in the past has arisen because the total area of conducting-through film-covered surface of the specimen has been very much larger than the area in which the film is broken under stress. When a calomel electrode is placed in an electrolyte in which the test specimen is immersed, the potential readings obtained represent essentially the potential of the relatively very large film-covered surface; the film-free surface is so small by comparison that it may not even be possible to detect any change of potential when the specimen is stressed.

At NBS this measurement problem was solved by coating an entire notched specimen with a non-conducting water-proof lacquer, then using a razor blade to remove a narrow band of lacquer at the root of the notch. With specimens thus prepared, the only potential being measured was that of the narrow band of metal at the root of the notch where the stress was concentrated. With fairly rapid application of stress, the film-free area then became a substantial fraction of the total non-lacquer-covered area, and the potential became more negative as the stress was increased. If the stress was held constant for some time, the solution potential generally reverted quickly to that of the unstressed metal. If the stress was increased rapidly, however, the measured potential tended to approximate that of a film-free surface as the point of fracture was reached.

References

1. For further technical details see "Film Rupture Mechanism of Stress Corrosion," by Hugh L. Logan, Jr., *J. Res. Nat. Bur. Standards*, 48 (1952) Feb.
2. R. B. Mears, R. H. Brown and E. H. Dix, Jr. Symposium on Stress Corrosion Cracking of Metals, Am. Soc. Test. Mat., Am. Inst. Mech. Eng. (1944) p. 323.

Boston Section Program Includes Talk by Fair

The program for the second meeting of the Greater Boston Section May 20 includes a paper entitled "Protective Coatings," by W. F. Fair, former Metropolitan New York Section chairman. The illustrated talk was formerly presented at the University of Texas.

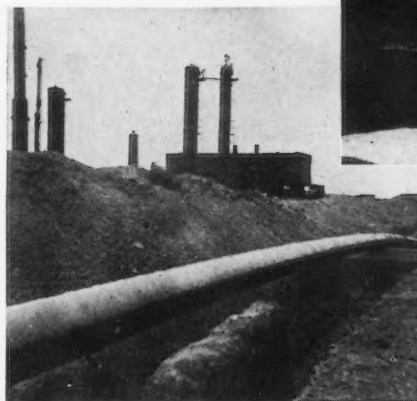
Seven to 9-inch armor steel is being inspected by use of three 24 million volt betatrons in Eastern and Midwestern steel foundries. The units, built for Army Ordnance Corps under supervision of U. S. Army Corps of Engineers, are estimated to have cost approximately \$250,000 each.

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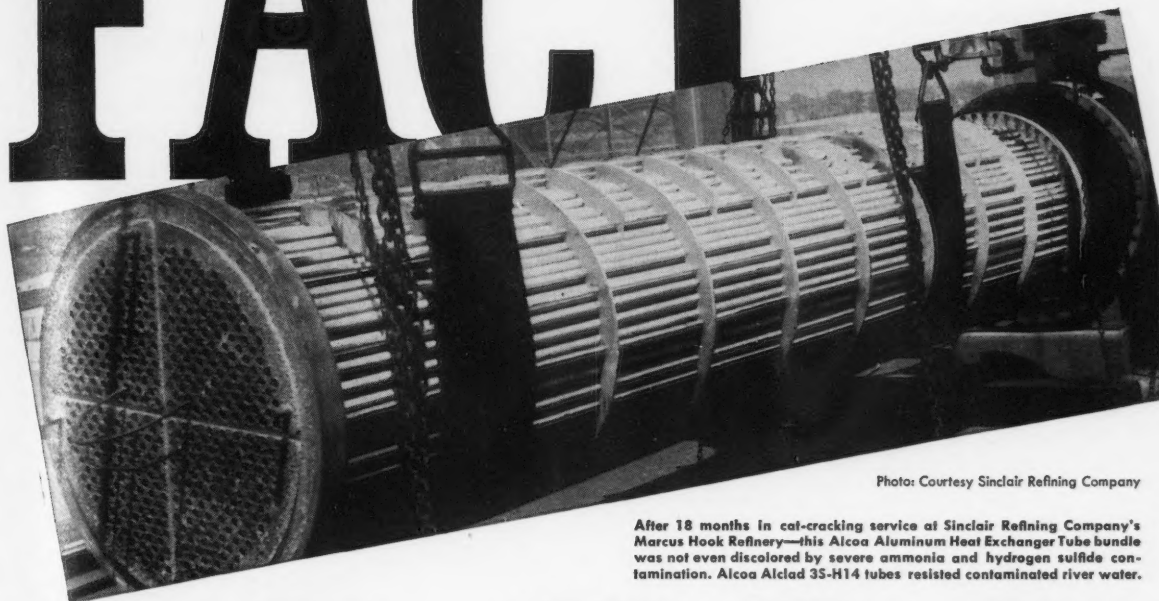


Photo: Courtesy Sinclair Refining Company

After 18 months in cat-cracking service at Sinclair Refining Company's Marcus Hook Refinery—this Alcoa Aluminum Heat Exchanger Tube bundle was not even discolored by severe ammonia and hydrogen sulfide contamination. Alcoa Alclad 3S-H14 tubes resisted contaminated river water.

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Formaldehyde
Furfural
Heptaldehyde
Acetic acid
Stearic, Palmitic, Maleic Oleic acids
Butyric acid
Naphtha

Ricinoleic acid
Acetanilide
Ammonia
Hydrogen Cyanide
Nitric acid (concentrated)
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Hydrogen Peroxide
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Use Alcoa Alclad 3S-H14 Heat Exchanger Tubes with fresh, brackish and salt-cooling waters

NACE

New Members and Changes of Address

• This list is published principally for use by NACE Regional and Sectional officers in keeping their mailing lists up to date.

(Additions and Changes Through
April 27, 1952)

CALIFORNIA

DRESSER, JR., THEODORE P., Abbott A. Hanks, Inc. 624 Sacramento, San Francisco 11, California.
FLYNN, HUGH F., Macco Corporation, 14409 Paramount Blvd., Paramount, California.
KERR, JAMES G., C. F. Braun & Co., 1000 S. Fremont Ave., Alhambra, California.
KURZ, FRED E., Service Coating Corporation, 217 North Lagoon Ave., Wilmington, California.
WING, PAUL A., Service Coating Corporation, 217 North Lagoon Ave., Wilmington, California.

CONNECTICUT

HYPIIA, JORMA, Box 219, Glenville, Connecticut.
STEVES, ARTHUR F., Box 966, New London, Conn.

DISTRICT OF COLUMBIA

WALTON, ROBERT E., Water Service Laboratories, Inc., 1514 "P" Street (rear) N.W., Washington 5, D. C.

FLORIDA

KELLY, KEITH V., International Minerals and Chemical Corporation, Mulberry Research Lab., Mulberry, Fla.

ILLINOIS

DURAND, EDWARD A., Ekco Products Co., 1949 N. Cicero Ave., Chicago 39, Ill.
FLAHERTY, JOHN T., Metallizing Engineering Co., Inc., 3431 So. Ashland Ave., Chicago, Ill.

PATZELT, HAROLD L., 7407 S. Union St., Chicago, Ill.

TUTTLE, LOREN W., Public Service Co. of Northern Illinois, 72 W. Adams, Chicago, Ill.

INDIANA

HUDSON, M. B., Shell Oil Co., Zionsville, Indiana.
JACKSON, ROBERT O., Ric-Wil Plastic Coating & Mfg. Corp., Box 414, Salem, Indiana.
WEISERT, EDWARD D., Haynes Stellite Co., Div. of Union Carbide & Carbon, 725 So. Lindsay, Kokomo, Indiana.

KANSAS

DAVISON, DON W., Surface Engineering Co., Inc. P. O. Box 2273, Wichita 1, Kansas.
DRIEG, KENNETH L., Shamrock Reconditioners, 5427 N. Broadway, Wichita, Kansas.

MARYLAND

COOPER, ALBERT H., P. O. Box 1471, Baltimore 3, Maryland.
JESTER, JOHN, Washington Suburban Sanitary Commission, 4017 Hamilton St., Hyattsville, Md.
MALONE, MAURICE O., 903 Church St., Baltimore, Md.
OLIVEIRA, JOHN F., Bethlehem Steel Co., Shipbuilding Division, Bethlehem Sparrows Point Shipyard, Sparrows Point 19, Maryland.

MASSACHUSETTS

LAWSON, MARTIN J., Koppers Co., Inc., 250 Stuart Boston, Mass.

MICHIGAN

BUTLER, R. EVERETT, Aurora Gasoline Co., 1215 South Dix, Detroit 25, Mich.
SINCLAIR, W. ALLISTAIR, The Detroit Edison Co. 2000 Second Ave.—Room 742, Detroit, Mich.
STUBER, HERBERT D., Dow Chemical Co., Midland, Michigan.

MISSOURI

BEIER, LEO J., Deady Chemical Co., 1316-18 St. Louis Ave., Kansas City 7, Missouri.
MALLEY, JR., HENRY A., Deady Chemical Co., 1316-18 St. Louis Ave., Kansas City 7, Missouri.
MALLEY, ROBERT J., Deady Chemical Co., 1316-18 St. Louis Ave., Kansas City 7, Missouri.
STONE, WILLIAM J., Deady Chemical Co., 1316-18 St. Louis Ave., Kansas City 7, Missouri.

NEW JERSEY

LUSSKIN, ABRAHAM, Everseal Mfg. Co., Inc., 475 Broad Ave., Ridgefield, New Jersey.

NEW MEXICO

COHN, ALBERT A., El Paso Natural Gas Co., Box 1384, Ja., New Mexico.
MIZE, WOODROW W., El Paso Natural Gas Co., Box 997, Farmington, New Mexico.
WARD, JACK L., Shell Oil Co., Box 1957, Hobbs, New Mexico.

NEW YORK

BRITTON, ORSON J., Pfaunder Co., 1000 West Ave., Rochester, N. Y.
HULL, JOSEPH W., Hawk-eye Works, Eastman Kodak Co., 20 Avenue E, Rochester, New York.
McCAMMON, THOMAS A., 155 E. 96th St., New York 28, N. Y.
O'NEILL, E. B., Shannon Brothers, 150 Broadway, New York 38, N. Y.
SUSSMAN, SIDNEY, Water Service Laboratories, Inc., 423 W. 126th, New York 27, N. Y.
WILCOX, ROBERT H., Conover-Mast Publications, Inc., 205 East 42nd, New York 17, N. Y.
WINCHESTER, CHARLES L., 130 Eighth Ave., Apt. 7E Brooklyn 15, N. Y.

OHIO

CHAPIN, DANIEL, Dow Chemical Co., Terminal Tower, Cleveland, Ohio.
CHRISTIE, DAVID E., Durlin Co., Inc., 420 N. Findley, Dayton, Ohio.
COATS, HARRY P., Firestone Steel Products Co., Akron, Ohio.
SOUTH, JOHN R., 1976 Seymour Ave., Cincinnati 37, Ohio.
TISSOT, ROBERT A., Maintenance Inc., West Liberty Street Extension, Box 35, Wooster, Ohio.

OKLAHOMA

AMSTUTZ, RAY W., Earlougher Engineering, 3316 East 21, Tulsa, Oklahoma.
BELL, JAMES C., Service Pipe Line Co., Service Pipe Line Bldg., Tulsa, Okla.
SMITH, CECIL O., The Carter Oil Co., Box 801, Tulsa, Oklahoma.

OREGON

BURNS, WOODROW T., John W. Burns & Sons Painting Co., 5140 N. E. 42nd Ave., Portland, Oregon.
WOOD, B. NEALLEY, Charlton Laboratories, Inc., P. O. Box 1048, Portland, Oregon.

PENNSYLVANIA

ADAMS, LUDWIG, Pittsburgh-Des Moines Co., Neville Island, Pittsburgh 25, Pennsylvania.

(Continued on Page 22)

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ACIPCO pipe has the lasting strength that enables it to survive continued corrosive attack, year after year, and to keep on giving the same dependable, economical service as the day it was installed. It is manufactured by the Mono-Cast centrifugal process in diameters 3-inch through 48-inch.

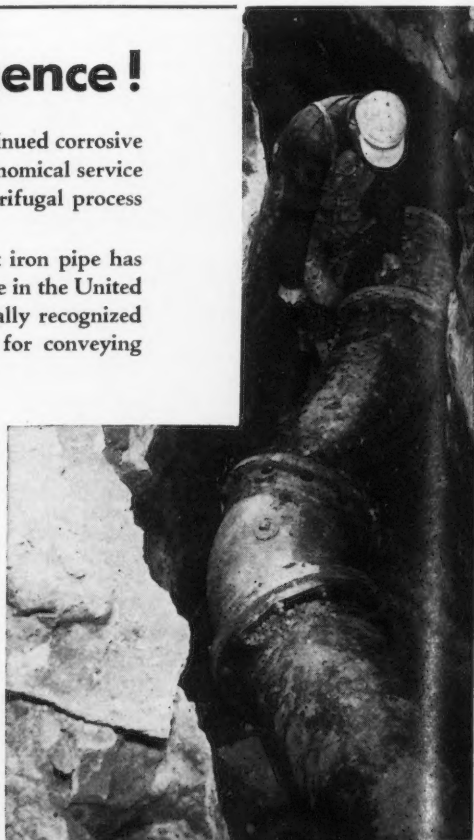
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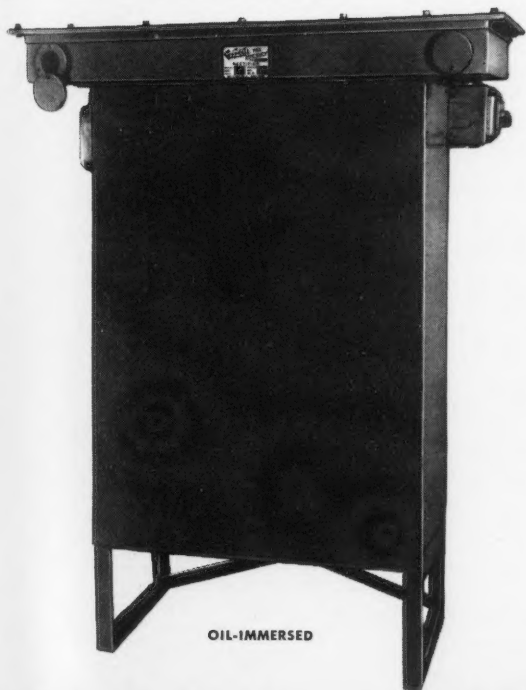
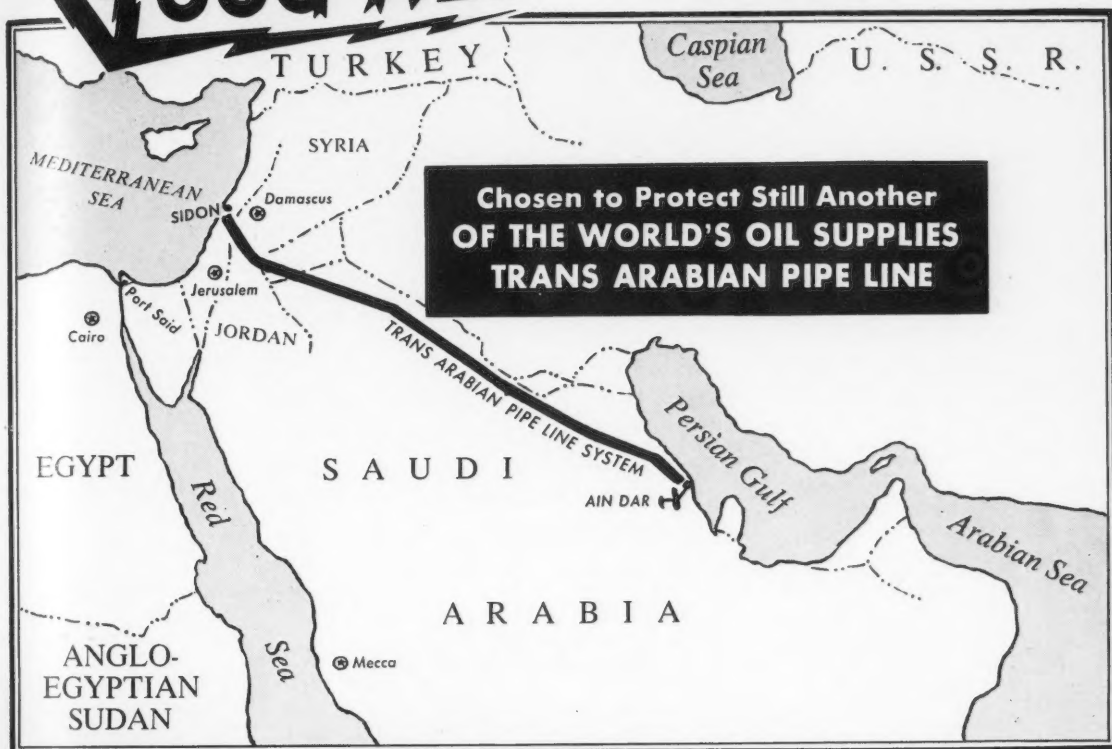
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New Members—

(Continued from Page 20)

BAKER, HAROLD D., Anderson-Prichard Oil Corp., 211 Third, Warren, Pennsylvania.
BEADELL, DONALD A., General Aniline & Film Corp., Product Development Dept., 22 Center Square, Easton, Pennsylvania.
BOOVA, AUGUSTUS A., The Atlas Mineral Products Co., Meritown, Pennsylvania.
BROWN, MELVIN H., Aluminum Co. of America, Aluminum Research Lab., Freeport Rd., New Kensington, Pennsylvania.
KALIN, SUMNER H., U. S. Steel Co. Research Lab., Vandersgrift, Pennsylvania.
MACDERMID, ELLIOTT, United Engineers & Constructors, Inc., 1401 Arch, Philadelphia, Pennsylvania.
MORRISON, JACOB B., Crucible Steel Co. of America, Midland Works, Midland Ave., Midland, Penna.
ROSENFELDT, MORRIS L., Water Service Laboratories, Inc., 4010 Sansom St., Philadelphia 4, Penna.
SHAFFER, JR., GEORGE E., Milton Roy Co., 1300 E. Mermald Lane, Philadelphia 18, Pennsylvania.
SHEPPARD, JR., WALTER LEE, Electro-Chemical Engineering & Manuf. Co., 750 Broad St., Emmaus, Pennsylvania.
STOSE, HAROLD F., John Wood Co., 100 Washington St., Conshohocken, Penna.
WANDERER, EDWARD T., Aluminum Co. of America, New Kensington, Pennsylvania.
SOUTH CAROLINA
HOWELL, JR., IRVIN N., Southern Bell Telephone & Telegraph Co., 405 Owen Bldg., Columbia, S. C.

TENNESSEE

FISHER, JR., CHARLES F., East Tennessee Natural Gas Co., Box 831, Knoxville, Tenn.
TEXAS
BERNARD, JR., CLOVIS, McCarthy Chemical Co., Box 1067, Beaumont, Texas.
BUTTERFIELD, PEARCE R., Transcontinental Gas Pipe Line Corp., Box 296, Houston, Texas.
CHAVIGNY, NEIL L., The Chavigny Co., 805 M & M Building, Houston 2, Texas.
COOK, CONRAD J., Houston Porcelain Enameling Co., 1130 Sidco Road, Houston, Texas.
COOK, EMERSON E., Texas City Refining Inc., Box 1271, Texas City, Texas.
COKER, STANLEY G., Coker Radio & Electronics, 909 Gulf Blvd., Velasco, Texas.
CUMMINGS, GEORGE H., Rohm and Haas Company, Box 672, Pasadena, Texas.
DOUGLAS, BURKE, Dow Chemical Co. Electrochemical Engineering Dept., Bldg. A-906, Plant A, Freeport, Texas.
EGAN, JAMES P., Texas Utilities Service Company, Box 1872, Fort Worth, Texas.
HARRIS, LUCIAN F., Pan American Pipe Line Co., Box 2228, Longview, Texas.
HYNES, HAROLD K., James E. Mavor Co., M & M Bldg., Houston, Texas.
JONES, EVERETT P., Texas Alloy Products Co., Box 19067, Houston 14, Texas.
LELEUX, C. J., Gulf Engineering Co., Inc.,

Box 1534, Corpus Christi, Texas.
MORGAN, HOMER C., Gulf Oil Corporation, Drawer 2100, Houston, Texas.
MCARVELL, JOHN H., Maceo Oil Tool Company, 1521 Prince, Houston 3, Texas.
PAREDES, FELIPE, El Paso Natural Gas Company, Box 1492, El Paso, Texas.
PIKE, GEORGE T., Houston Natural Gas Corporation, Petroleum Building, Houston, Texas.
ROWAN, ROBERT L., Rowan & Buchanan, 6006 Ardmore Street, Houston, Texas.
ROWE, JR., JOHN A., Gulf Oil Corporation, 5311 Kirby Drive, Houston 5, Texas.
SCHOOVER, WAYNE D., Morrow Engineering Specialty Co., 324 Hathaway, Houston, Texas.
SHELTON, JOHNNY H., National Tank Co., Box 665, Midland, Texas.
STEELE, JAMES E., Bethlehem Steel Company, Box 3031, Beaumont, Texas.
THOMPSON, FRANK C., Texas Coating Company, 4620 Telephone Rd., Houston 17, Texas.

WISCONSIN

CALE, DUTRO C., 1028 E. Juneau Avenue, Milwaukee 2, Wisconsin.
FOREIGN
COLEMAN, A. R., The Bell Telephone Co. of Canada, 1050 Beaver Hall Hill, Rm. 1429, Montreal, Quebec, Canada.
HALL, WILFRED N., Dominion Tar and Chemical Co., Limited, 2240 Sun Life Bldg., Montreal, Quebec, Canada.
HORNE, A. N., Trans-Northern Pipe Line Co., 21 Dundas Square, Toronto, Ontario, Canada.
TECKOE, JR., JOHN E., Windsor Utilities Commission, 149 Chatham West, Windsor, Canada.
JENNINGS, JOHN W., Colonia Americano E-5 N. Rosita, Coahuila, Mexico.
PETRASHUK, PETER, C. A. Energia Electrica de Venezuela, Apartado 146, Maracabo, Venezuela.

CHANGES OF ADDRESS

(Old Address Follows New in Parentheses)
CALIFORNIA

RAASCH, DALLAS G., La Mesa, Lemon Grove, Spring Valley Irrigation District, Box 518, La Mesa, California (4769 Spring St.)
SHELTON, M. J., La Mesa, Lemon Grove & Spring Valley Irrigation Dist., Box 518, La Mesa, California (4769 Spring St.)
STRAUDERMANN, HAROLD P., 2734 Petaluma Ave., Long Beach 15, California (National Lead Co., 3113 E. 26th St. Los Angeles 23, Calif.)
TOMPKINS, JR., ALBERT H., Superior Tank & Construction Co., 6155 So. Eastern Ave., Los Angeles 22, Calif. (Chancellor-Cannfield Midway Oil Co., 4549 Produce Plaza West, Los Angeles 11, Calif.)
RANKIN, NORMAN K., 2409 Elm Ave., Manhattan Beach, Calif. (Polyken Indust. Tape Dept., Bauer & Black Co., 222 W. Adams St., Chicago 6, Ill.)
FORD, CHARLES D., 308 Lincoln Ave., Palo Alto, Calif. (Electro Rust-Proofing Corp.,

1713 S. California Ave., Monrovia, Calif.)
EDWARDS, ROBERT W., The Republic Supply Co. of Calif., 1919 Williams St., San Leandro, California (1401 Park Ave., Emeryville, Calif.)
MOLLER, JOHN H., The Republic Supply Co. of Calif., 1919 Williams St., San Leandro, California (1401 Park Ave., Emeryville 8, Calif.)

DELAWARE

EVANS, JR., HERBERT V., Alloy Steel Products Co., Inc., 226 West Ninth St., Wilmington, Delaware (318 Investment Bldg., Pittsburgh 22, Pennsylvania)

FLORIDA

BIDDISON, P. McDONALD, Box 701, Arlington, Florida (1341 South Boston, Tulsa 3, Oklahoma)

ILLINOIS

GREEN, JEROME, 7027 S. Jeffery Ave., Chicago 49, Ill. (National Aluminate Corp., 6216 W. 66th Pl., Chicago 38, Ill.)
HOLSINGER, FRED J., Corn Products Refining Co., Argo, Cook Co., Illinois (201 N. Wells St., Chicago, Ill.)
LARSON, JOHN A., Orrington Hotel, Evanston, Ill. (Rest-Oleum Corp., 2425 Oakton St.)
SCHMIDT, BURTON J., 659 Deerpath Drive, Deerfield, Ill. (220 Central Park Ave., Wilmette, Ill.)

LOUISIANA

CARMICHAEL, JR., CHARLES J., 441 North Union, Opelousas, Louisiana (Gulf Ref. Co., Production Div., Box 234 Lafayette, Louisiana)
JAY, LESTER L., 208 1/2 Philip St., New Iberia, La. (The Texas Co., P. O. Box 457)
NEWTON, WILLIAM E., 5119 Kendall Drive, New Orleans, La. (1204 Napoleon Ave., Apt. 1)

NEW JERSEY

CROBAUGH, ALBERT O., Curtiss-Wright Corporation Propeller Div., Caldwell, New Jersey (Rocket Dept.)

NEW YORK

LEWIS, SIDNEY A., U. S. Stoneware Company 60 East 42nd St., New York 17, N. Y. (Ray Miller Inc., 252 North 10th St., Newark, New Jersey)
WESTERHOFF, R. P., Ford, Bacon & Davis, Inc. 39 Broadway, New York 6, N. Y. (H. E. Whitaker, Vice Pres. & Chf. Engr.)

PENNSYLVANIA

BURNS, CHESTER P., 4518 Brownsville Road, Pittsburgh 27, Pennsylvania (Atlas Mineral Products Co., Meritown, Pa.)
HAMILTON, HUGH L., The A. V. Smith Company 121 Coulter Ave., Ardmore, Pennsylvania (370 Trevor Lane Bala-Cynwyd, Pennsylvania)
KENDALL, V. V., National Tube Division, U. S. Steel Co., Box 266, Pittsburgh 30, Pennsylvania (National Tube Company)
RINGER, FRANCIS, The A. V. Smith Company, 121 Coulter Avenue, Ardmore, Pennsylvania (370 Trevor Lane, Bala-Cynwyd, Pennsylvania)

TENNESSEE

HECHT, JR., LEON M., Woodlawn Drive, Nashville, Tenn. (214 W. 92nd St., Apt. 2A, New York, New York)
SIMPSON, N. H., 140 Placer Lane, Oak Ridge, Tenn. (Consol. Vultee Aircraft Corp., Grants Lane, Fort Worth 1, Tex.)

TEXAS

HUESEMAN, ROBERT L., Middle West Coating & Supply, 3018 Shenandoah, No. 6, Houston, Texas (207-A Daniel Building, Tulsa, Oklahoma)
KELLY, J. DYCHE, 2438 South Blvd., Houston, Texas (Hydraulic Equipment Co., 1311 North Shepherd Dr.)
KIRSTEN, K. W., Temco Aircraft Corp., Box 5191 Dallas, Texas (Texas Eng. & Mfg. Co., Inc.)
STAFFORD, JAY D., National Tank Co., Box 665, Midland, Tex. (Box 1387, Odessa, Tex.)
WADE, O. W., Transcontinental Gas Pipe Line Corp., P. O. Box 296, Houston, Texas (3100 Travis Street)

FOREIGN

GERSON, FREDERICK T., 70 Crawford St., Toronto, Ontario, Canada (John Dale Ltd., Brunswick Park Rd., New Southgate, London, N. 11, Eng.)
SCHMECKLE, DUANE A., Shell Oil Company Box 100, Calgary, Alberta, Canada (P. O. Box 271, Donaldsonville, Louisiana)
GERRARD, JOHN S., c/o 41 Merton Road Prestwick, NR. Manchester Lanes, England (c/o Kuwait Oil Co., Ltd., Ahmadi, Kuwait, Persian Gulf)
SCHERESCHESKY, P. L., Gaz de France, Center Des Recherches, 62, Rue de Courcelles, Paris, France
MOYAR, ROBERT E., Standard-Vacuum Petroleum, Maatschappij, Prod. Dept., Sungei Gerong, Palembang, Sumatra, Indonesia (Pendopo)
SCARPA, PROF. OSCAR, Via Pileo 7, Cernobbio (Como) Italy (1st. Di Elett. chimica Del Politecn. Dalmine S.P.A. Piazza Leonardo I.C.O. Da Vinci 32, Milan, Italy)
STOBAUGH, JR., ROBERT B., c/o Creole Petroleum Corp., Las Piedras, Edo. Falcon, Venezuela, S. A. (Caripito, Monagas)

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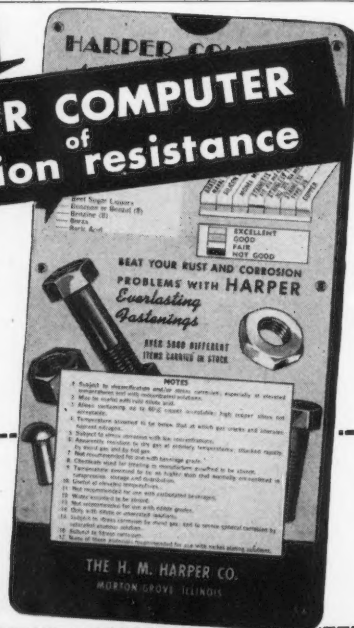
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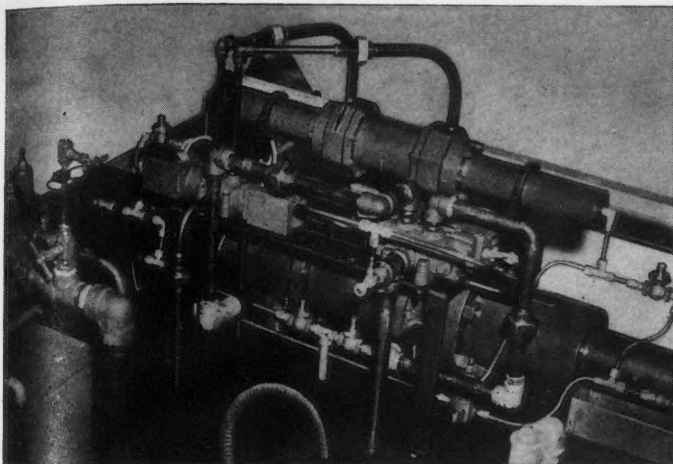
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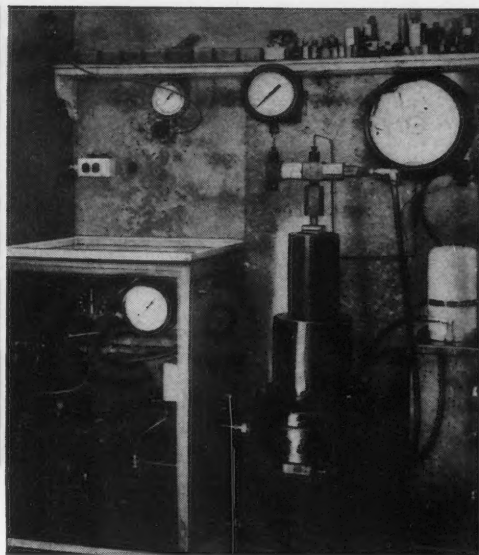
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NICKEL ALLOYED STEELS, heat treated to high strength values, provide parts of extreme toughness and reliability for Harwood intensifiers, such as this typical installation in a glass company's plant.



TYPE 316 STAINLESS IS UTILIZED in Foxboro indicators and recorders such as these shown in use with a Harwood intensifier.

NICKEL ALLOYS HELP MAKE PRESSURES UP TO 2000 ATMOSPHERES COMMERCIAL PRACTICAL

New equipment and processes now being used to explore pressures
up to 10,000 ATMOSPHERES

Heretofore, the highest pressure commonly used industrially has been for ammonia synthesis at 1000 atmospheres...

Now, however, pressures of at least 2000 atmospheres (30,000 p.s.i.) already serve production processes, and apparatus capable of delivering pressures up to 200,000 p.s.i. has been designed by the Harwood Engineering Company of Walpole, Mass.

To secure essential stamina in high pressure heads of intensifiers, as well as in reactor vessels, valves and fittings, Harwood engineers fabricate these parts from nickel alloyed steels. The types used, include S.A.E. 4340 (nickel-chromium-molybdenum), S.A.E. 3250 (1.75% nickel-chromium) and S.A.E. 3450 (2% nickel-chromium). They are heat treated to very high strength, with a double tempering treatment after liquid-quenching.

Developed for use in conjunction with these new high pressure units are instruments for measurement and control... produced by The Foxboro Company of Foxboro, Mass.

Foxboro utilizes a nickel-alloyed stainless steel, Type 316, containing 17% chromium, 12% nickel and 3%

molybdenum, for heavy duty helical elements that determine pressures up to 80,000 p.s.i. Results in service prove the correctness of choosing Type 316, since it resists corrosion from a wide variety of chemicals, and combines good spring qualities with high yield point after suitable cold working.

Harwood, also, uses Type 316...sometimes to line composite tubes, and sometimes as solid tubing to handle pressures up to 200,000 p.s.i.

Thus, nickel-containing alloys play an important role in developments which may open new industrial frontiers.

At present, the bulk of nickel produced is being diverted to defense. Through application to appropriate authorities, nickel is obtainable for the production of engineering alloy steels for many end uses in defense and defense supporting industries. Counsel and data on alloys containing nickel, for your present or future projects, may be had for the asking. We invite your inquiries.



THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
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NACE**New Corporate Members**

JOHN W. BURNS & SONS PAINTING CO.

Portland, Oregon
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Houston, Texas
William H. Edwards, Rep.

SURFACE ENGINEERING COMPANY, INC.

Wichita, Kansas
Don W. Davison, Rep.

Annual Sea Horse Conference Scheduled

The 1952 Annual Informal Conference of the Sea Horse Institute was scheduled for June 4-6, at Wrightsville Beach, N. C. The proposed program included, "Corrosion of Heat Exchanger Tubes by Polluted Waters," "Cathodic Protection," "Protective Coatings," and "Miscellaneous Topics." Advance questions were requested and members asked to suggest changes and improvements in the program.

Waterfront Structures Deterioration Subject At Miami Beach Meeting

The program for the June 11-13 Marine Borer and Prevention of Deterioration in Waterfront Structures Conference at Miami Beach, Fla., contains the following items of corrosion interest:

June 11—Office of Naval Research Interest in Prevention of Deterioration in Marine Structures by Rear Adm. C. M. Bolster, USN. Deterioration Problems in Marine Structures by J. T. Reside, Bureau of Docks, Director, Fleet Facilities Division, Washington, D. C. Corrosion Problems in Waterfront Structures by F. L. LaQue, The International Nickel Co., Inc., New York.

Other items include various aspects of the technology related to the conference subject including biological data and wood preservation information.

Reservations for the meeting can be made by writing to the Manager, St. Moritz Hotel, 1565 Collins Ave., Miami Beach, Fla.

Atkinson Elected

Roy G. Atkinson was elected chairman of the General Committee for 1952 in a joint meeting of the General and Technical Committees of the Denver Committee on Electrolysis. Mr. Atkinson is a distribution engineer with the Public Service Company of Colorado, Denver, Col. He succeeds Kenneth A. Day who was the 1951 chairman.

Magnolia Refinery at Beaumont Toured by Sabine-Neches Section

A field trip through the Magnolia Petroleum Co. refinery at Beaumont, Tex. was a highlight of the April meeting of the Sabine-Neches Section. The trip included visits to all points of interest to the members and took about 2½ hours. Nineteen members and three guests attended.

The business meeting was held at the Golden Arrow restaurant. The May meeting, designated a social meeting was held May 23 at Orange, Texas. Ladies were invited.

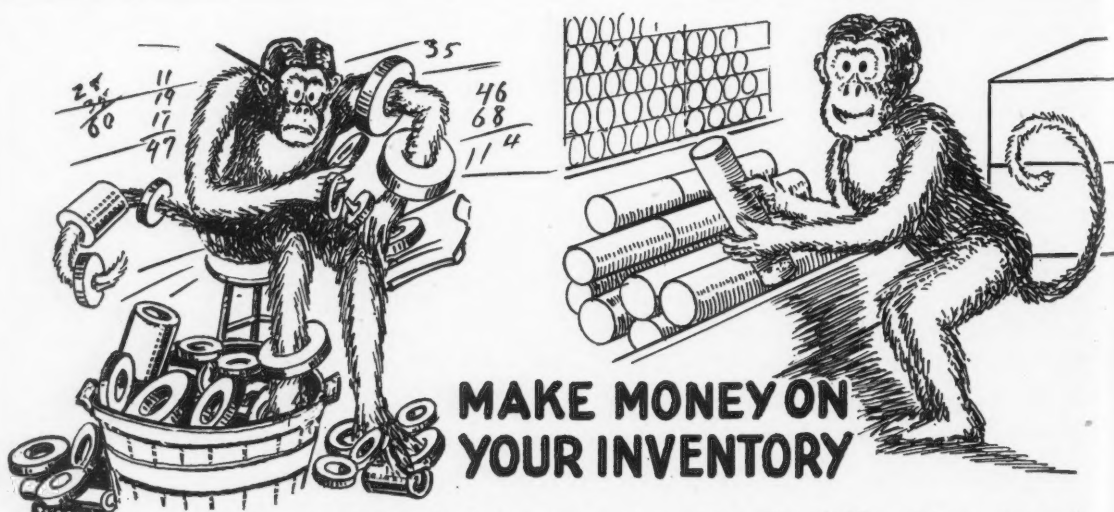
The nominating committee presented a slate of officers that was voted on at the May meeting.

Desulfurization and Dehydration Discussed At Oil Recovery Meeting

Included in the program of the Fourth Oil Recovery Conference, Hogg Memorial Auditorium, Austin, Texas, was the following paper: Desulfurization and Dehydration of Natural Gas by LeRoy Culbertson and J. S. Connors, Phillips Petroleum Co., Bartlesville, Okla.

The May 8-9 meeting was sponsored by the Texas Petroleum Research Committee.

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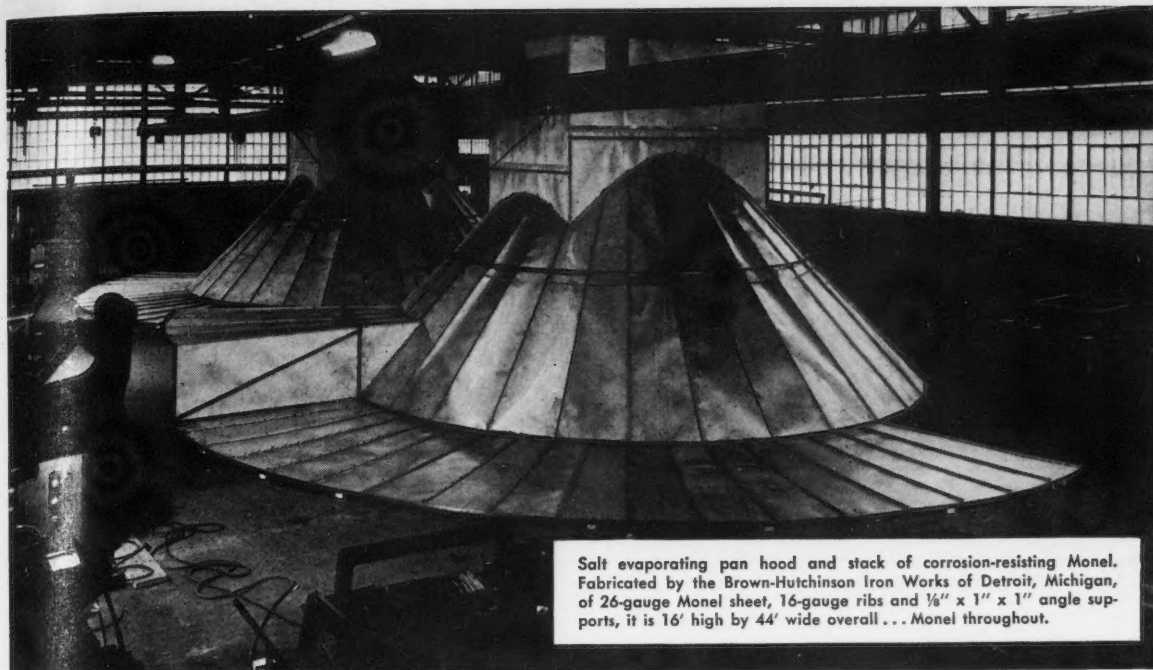
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Nickel  Alloys

NEW PRODUCTS — Materials — Service — Literature

Prufcoat Laboratories, Inc., Cambridge, Mass. has issued a new general catalog describing its entire line of coatings. A list of chemical agents to which the coatings are resistant is included. Data given are keyed to available technical bulletins issued by the company.

Gammage, an instrument using isotope emissions, has been used to chart the extent of corrosion in sulfite pulp digesters eliminating a tedious and costly inspection by mechanical means. Made by Isotope Products Ltd., Oakville, Ontario, the instrument uses gamma rays of Cobalt 60, iridium 192 and other isotopes produced at the Canadian atomic energy installation at Chalk River.

ACP Phosphate Coating Chemicals and Processes are described in a 12-page bulletin issued by American Chemical Paint Company, Ambler, Pa. The pamphlet covers paint bonding, rust proofing, protection of friction surfaces, extrusion and drawing lubrication and a table of government specification equivalents to company formulations.

Silver is being clad on stainless steel by American Cladmetals Co., Arch St., Carnegie, Pa. The Kinney process used by the company makes a permanent bond. The material is used in the electronics field because of the high conductivity of the silver and the corrosion resistance of the steel.

Carey Company's Reference List for Asphalt, Asbestos and Magnesia Products covers 800 building materials and industrial products. The manual shows Army, Navy, MIL, Federal, ASTM and other specifications corresponding to Carey products. Copies can be obtained by writing to the company, Dept. FRM, Cincinnati 15, Ohio.

Kelite Products, Inc., 1250 North Main Street, Los Angeles 12, will send on request its brochure explaining its cleaning and processing materials using the Kelite pH Control principle.

Crown Industrial Products Co., Park and Borden Ave., Sycamore, Ill., is producing Crown Rust Inhibitor, a proprietary material with an animal fat base, designed to prevent rust. It is applied from a 12-ounce spray container and dries to a tacky finish. Protection up to 72 hours in a standard salt spray test is claimed. It can be applied to wet or dry surfaces but has been found more effective on moist surfaces.

Erwood, Inc., 1770 Berneau St., Chicago 13, has developed a device called Electro-Probe designed to amplify sound received through a vibration pick-up probe. Because it is sensitive only to vibrations at point of contact it is unaffected by airborne noises. Audible comparison of vibration sounds within a range of 60 decibels and meter visual indication is provided.

Hydrocide S. X. Colorless, a silicone water repellant is designed to make masonry resist moisture. L. Sonneborn Sons, Inc., 80 Eighth Ave., New York

11, manufacturers said it makes all types of above-grade porous masonry water repellant immediately after drying. It is invisible, colorless, and will not wash or wear away.

How to Use Schedule Numbers in Power Piping Design, a bulletin issued by Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, describes, among other things, methods of selecting pipe wall thickness.

Minnesota Mining and Manufacturing Co., 900 Fauquier St., St. Paul 6, Minn., has issued an eight page booklet on protecting buried pipes from corrosion with "Scotch" plastic tapes No. 21 and 22. High speed machine and hand wrapping techniques are described. Case histories of uses of the tape and tables listing the physical and electrical properties of the tapes are given.

Industrial High Pressure Tube Fittings manufactured by The Deutsch Company, 7000 Avalon Blvd., Los Angeles 3, are described in a new catalog. Materials used include plated steel, brass, Dural and stainless steel.

Murphy & Miller, Inc., Chicago, Ill., has introduced a new humidity testing cabinet which they state will supply quickly and accurately, relative humidity between 20 and 95 percent in the temperature range 35 to 185 degrees F. Features include a refrigerating unit and an electrical heating unit, a high capacity condensing system to eliminate condensation caused by rapidly changing temperatures, adjustable shelves and electrical outlets. The cabinet contains 27 cu. ft. working space.

Sellers Injector Corp., Philadelphia, Pa., is marketing a new jet cleaning unit able to throw a solid stream of hot detergent or solvent for a distance of 20 ft. By changing hoses and nozzles, the same unit can be used to produce a high impact jet of hot water, effective at distances up to 35 ft. All heating and propelling is done within the unit by ordinary plant steam, without heaters, pumps or any moving parts.

Turco Products, Inc., Los Angeles, Calif., has formulated a high-speed dye penetrant process to be used with production line inspection techniques. First the part is sprayed with a red penetrating dye. The dye penetrates into cracks and flaws which extend to the surface of the part. The red surface dye is then removed by vapor degreasing. Next a white developer is sprayed on the part. The red dye which has penetrated cracks and other flaws then bleeds into the developer, marking the flaw.

Welding fittings made by the Tri-Clover Machine Co., Kenosha, Wis., for use with stainless steel light gauge O.D. tubing are discussed in a booklet published by the company. The illustrated catalog shows 45-degree laterals, crosses, Y's caps, eccentric and concentric reducers and other fittings. Tables and dimensions of the various fittings are given.

All-State Welding Alloys Co., Inc., White Plains, N. Y. has published a manual which gives a brief explanation of brazing. Best ways of preparing the metals for brazing are given. Diagrams are used to aid in showing different techniques. The book states that almost all metals can be brazed.

International Nickel Co., has published two booklets: "A Theory of the Mechanism of Rusting of Low Alloy Steels in the Atmosphere," and "Practical Nickel Plating." In the first booklet, it is postulated that corrosion rate depends on the quality and quantity of water reaching the steel surface. Relatively insoluble corrosion products decrease the amount of soluble constituents in the water and thereby decrease corrosion. These corrosion products are different on different steels. For this reason it is maintained that although two different kinds of steel are subjected to exactly the same conditions of climate, the environment surrounding the unrusted surface is not the same. "Practical Nickel Plating" is a 44-page booklet which gives a brief summary of the applications of nickel plating; plating solutions; conditions and properties of deposits; preparation of basis metals for plating; plating difficulties and their correction; and other phases and problems of nickel plating.

Texteam Corp., Houston, Texas, has developed a high pressure chemical injector pump which will produce from 100 to 20,000 lbs. discharge pressure. Discharge pressures are regulated by controlling feed pressures between a range of 5 to 50 lbs. The pump weighs 62 lbs. and is supplied with 1/4 or 1/2-inch Stellite pistons and valves when used for sustaining high pressures.

Solar Aircraft Co., 2200 Pacific Highway, San Diego 12, Cal., states their process of coating metals with ceramics makes it possible for parts made of alloys rich in strategic elements to last longer under high temperatures by preventing oxidation and corrosion. The company maintains that more easily obtainable and lower grades of steels can be substituted for higher alloy steels if the lower grade steels are ceramic coated. Some uses for ceramic coated metal, in addition to aircraft parts, are: petroleum refining and chemical process industries; locomotive engine parts, industrial gas turbine parts, heat exchangers, industrial furnace parts and many other articles.

Galvalloy, a galvanizing coating bar, is said by the manufacturers to bond to metal surfaces without the use of flux, sandblasting or cleaning. The Metalloy Products Co., distributors of the product, state that it is only necessary to pre-heat the base metal before applying the galvanizing coating bar and that pot metal, aluminum, and magnesium can be galvanized. The company maintains the coating will not peel, burn or chip off.

Midwestern Engine and Equipment Co. recently announced the appointment of Jay G. McCray as general manager of

(Continued on Page 27)

New Products—

(Continued from Page 26)

the firm's Oklahoma City, Okla. branch office, and the appointment of Fred J. Steinmiller as the company's sales representative in Chicago. Mr. Steinmiller will promote the sale of Midwestern's pipe line wrapping and supply items for the Indiana, Illinois, Iowa, Wisconsin and Minnesota area. Former manager of Midwestern's Oklahoma City branch office was T. E. Mitchell.

Metallizing Engineering Co., Inc., Long Island City, N. Y. has issued two booklets: an instruction manual on the use of their type 4E and type 5E metallizing guns and a publication explaining the procedures the company has developed to meet a wide range of corrosion problems. The manual contains cutaway diagrams of the gun and equipment and pictures of the gun in use. Operating instructions, care of the gun, use of special equipment, spraying tables and a listing of metallizing accessories are also included. The other publication explains the "Metco Systems" or procedures the company has developed. These systems generally consist of spraying pure metallic zinc or aluminum coatings which are then treated with special organic materials. The various corrosive environments are given along with the Metco Systems recommended to combat them.

The firm also announces a new development in the field of low pressure, vacuum, slush or "lay-up" molds for laminations. A Metco spray gun is used to cover a plaster master mold. Spramold wire, made of a low melting-point metal alloy is first applied approximately .040 thick. Next a .030 coating of aluminum bronze alloy is sprayed on. This is followed by another .040 coating of Spramold wire. The mold is said to reproduce minute detail in the master mold.

PERSONALS

C. Laurence Warwick, executive secretary of American Society for Testing Materials and its administrative head since 1919 died Wednesday, April 23, following what was believed to be a heart attack. His death came about an hour after he presided at a dinner honoring the retiring treasurer of the society. He had made many contributions to the field of standardization and research in materials. He was a member of several engineering societies.

Robert J. Painter has been named treasurer of American Society for Testing Materials succeeding John K. Rittenhouse, who has retired after 43 years of service with the group.

Russell W. McIntosh has been named Corrosion Products Representative for Western and Pacific Coast Districts of Dresser Manufacturing Division. Originally from Portland, Oregon, Mr. McIntosh attended Benson College and completed a course in industrial engineering at University of Southern California. He is a member of NACE and the American Water Works Association. He will make his home in Los Angeles, Cal.

Walter E. Remmers has been elected vice-president—Alloys Division, Union

Carbide and Carbon Corp. He joined Union Carbide in 1936, was president of Electro Metallurgical Company since 1948 and president of United States Vanadium Company since 1950.

Kenneth H. Hannan has been elected treasurer of Union Carbide and Carbon Corp. He has been with the corporation since 1936.

Morse G. Dial has been elected president of Union Carbide and Carbon Corp. A graduate of Cornell University, he has been executive vice-president of the firm since 1951.

Robert L. LaFortune has been named representative of Reilly Tar & Chemical Corp., in the Oklahoma, Arkansas and Colorado territories for protective coatings, creosote and roofing pitch. He is a native and resident of Tulsa, and attended University of Tulsa and Purdue from which latter school he received a bachelor's degree in chemical engineering.

Anthony J. Allen has been named Eastern sales manager for Wall Colomony Corp. with headquarters in New York.

Paul D. Merica, formerly executive vice-president of The International Nickel Co. of Canada, Ltd. has been elected president of the company. John F. Thompson, chairman of the board, retired as president.

Gus Vogler, NACE member living in Lafayette, La., is now representative for Brance-Kracy Co., Inc., Houston, Tex. Mr. Vogler was formerly with Dowell, Inc. For the time being, Mr. Vogler will make his home in Lafayette.

The National Association of Corrosion Engineers now has more than 3200 members.

Single copies of most back issues of Corrosion are available to NACE members at 50c each and to non-members at 75c each.

CORROSION MEETINGS

1952

June

20-21—ASM Biennial Pennsylvania Interchapter Meeting, State College, Pa.

23—ASTM 50th Anniversary Meeting, New York, N. Y.

Sept.

4-6—AIChE (Regional Meeting) Chicago, Ill.

8-12—Instrument Society of America, Cleveland, Ohio.

Dec.

7-10—AIChE, Annual Meeting, Cleveland, Ohio.

1953

Mar.

2-6—ASTM Spring Meeting and Committee Week, Detroit, Mich.

April

20-22—Metal Powder Association, Cleveland, Ohio.

June

29-July 2—ASTM Annual Meeting, Atlantic City, N. J.

Sept.

21-25—Instrument Society of America, Chicago, Ill.



REPRINTS

Cathodic Protection and Pipe Lines

A Proposed Standard Method for Measuring the Electrical Resistance of Pipe Line Coatings by W. F. Rogers, B. H. Davis, Lyle Sheppard, Donald Bond, L. G. Sharpe, E. R. Allen and P. T. Miller.

Mitigation of Corrosion on City Gas Distribution Systems by A. D. Simpson, Jr.

Paints and Coatings

The Effectiveness of Paint in Suppressing Galvanic Corrosion by G. W. Seagren, G. H. Young and F. L. LaQue.

Tests, Properties of Corrosion Preventive Lubricants for Lead Sheathed Cables in Underground Ducts—A Discussion by Howard S. Phelps and Frank Kahn.

Petroleum Production and Storage

Corrosion in Condensate and in High Pressure Sweet Oil Wells by R. C. Buchan.

The Use of Ammonia in Control of Vapor Zone Corrosion of Storage Tanks by F. T. Gardner, A. T. Clothier and F. Coryell.

Miscellaneous

Causes of Corrosion in Airplanes and Methods of Prevention by N. H. Simpson.

Cathodic Protection of an Active Ship in Sea Water by K. N. Barnard and G. L. Christie.

Corrosion of 18-8 Alloy Furnace Tubes in High-Temperature Vapor Phase Cracking Service by E. Q. Camp, Cecil Phillips and Lewis Gross.

Salt Spray Testing Bibliography by Lorraine Voight.

The Cost of Corrosion to the United States by H. H. Uhlig.

Why Metals Corrode by H. H. Uhlig.

Reprints of Technical Practices Committee Reports

Report of TP-12 on Electrical Grounding Practices.

First Interim Report of TP-6G on Surface Preparation of Organic Coatings. Publication 50-5.

Stress Corrosion Cracking in Alkaline Solutions. Report of TP 5 C—Sub-Surface Corrosion by Alkaline Solutions. Publication 51-3.

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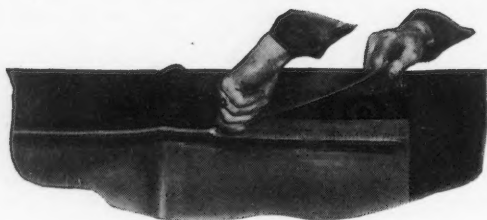
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Now—you simply "pull the zipper" on corrosion problems



Dresser ZIPCOAT for welded joints zips over weld area, fits closely to the pipe. 30" lengths.

NEW DRESSER ZIPCOATS* GIVE SURE PROTECTION, SUPERLATIVE DIELECTRIC STRENGTH

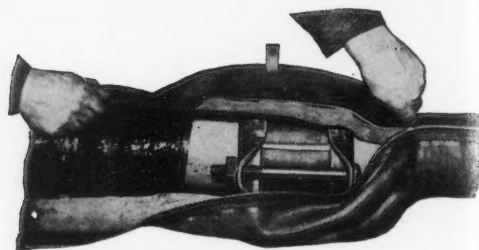
"As easy as zipping up a jacket" is what workmen say about Dresser's new ZIPCOATS. They install ZIPCOATS in 1/10 of the time it takes to coat a joint. You get protection that equals or exceeds that offered by the mill or yard-wrapped pipe.

And look at the hazards you avoid: there's no flame; no heating, hauling or messy application of hot stuff; no danger from fumes or burns.

Can be installed in any weather.

Write today for descriptive material and price list.

*Every ZIPCOAT complete with anaerobic microbiological corrosion inhibitor and cold sealing compound. ZIPCOAT is a trade mark of Dresser Manufacturing Division.



Dresser ZIPCOAT for couplings is easy to install over joint and pipe ends—all in one quick operation. Has bleeder valve to vent air during backfilling.

Dresser ZIPCOAT for insulating joints is made like the ZIPCOAT for welds, but in ten-foot lengths. Installing one on each side of an insulating joint that's protected with a ZIPCOAT for couplings gives ultimate protection. Eliminates costly boxing and filling with dope. Immediate trench backfill saves time.



**Install Dresser Insulating Couplings
IN MINUTES**

Dresser Style 39 Insulating Couplings with new plastic gaskets insulate effectively and are the simplest insulating type joint to install. Sizes $\frac{3}{4}$ " to 30" and up.



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Fast bonding, giving low resistance with preformed Dresser Bond and 5-second chemical welding method. Needs no special skill, no bulky equipment. Makes homogeneous weld area, eliminates surface contact variables. Compact kit of 50 preformed bonds includes all materials needed for installing.

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Corrosion Abstracts

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1. GENERAL

1.2 Importance

1.2.1

Education Committee Aims to Demonstrate Importance of Corrosion Technology. NORMAN HACKERMAN, Chairman, Committee on Education, National Association of Corrosion Engineers. *Corrosion*, 7, No. 10, 321 (1951) Oct.

The long range objective of the Education Committee is to demonstrate to educational institutions there exists a flourishing and important field of technology; one in which capable, well-trained personnel are needed. If the institutions can be convinced of this need, it is likely they will be amenable to the establishment of regular credit courses on corrosion in their curricula. Another objective unrelated to formal courses is to develop lists of capable speakers and topics for use by NACE sections and regions in programs. This includes providing information on popular talks such as might be given on radio or television and in keeping up to date a list of motion pictures especially devoted to the subject of corrosion.

1.2.2, 1.3

Surface Preparation and Paint Application Economics. A. J. LIEBMAN. New York Univ. College of Engineering, 2nd Symposium on Varnish & Paint Chem., 1949, 49-65; also in *Paint Var. Prod.*, 41, No. 3, 18-22 (1951) cf. *Review*, 1950, 531. A review from an engineering standpoint.—RPI.

1.2.2

Control of Maintenance Costs. R. S. STEWART AND H. A. GUSTAFSON. Standard

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CODE OF AGENCIES SUPPLYING CORROSION ABSTRACTS

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario, Canada.

AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BLR—Battelle Library Review, Battelle Memorial Institute Library, 505 King Ave., Columbus, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EL—Electroplating, 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California, 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum, 26 Portland Place, London W#1, England.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana. Associazione Italiana di Metallurgia. Via S. Paolo, 10, Milano, Italia.

MR—Metals Review, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts, United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers, 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.

TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

Oil Co. (Ohio). Preprint, API, 14th Mid-Year Meeting Rfg. Div., Houston, 14 pp. April 4-7, 1949.

A cost-control procedure is outlined, covering the functions of an automatic business-machine installation and actual maintenance-cost reports for a refinery. These include labor and materials reports for maintaining and operating producing and service units in the refinery; expenditures of labor and material further sub-divided by type of equipment, period of time and amounts of material used; and labor expenditure reports tabulated by individual jobs, crafts involved, man-hours, individual piece of equipment and amount of overtime.

1.2.2, 5.1

Preventive Maintenance. R. W. TRYON. Esso Standard Oil Co. Preprint, API, 14th Mid-Year Meet., Refg. Div., Houston, April 4-7, 1949, 10 pp.

A pattern of maintenance organization followed in Esso Standard Oil Co. refineries employs a zone system wherein the zones (the number and size depending upon the magnitude of the investment to be maintained) are supervised by zone engineers who receive reports from area engineers, who provide liaison between field problems and service groups and who coordinate the functioning of the crafts within their area. Excellent lines of communication exist for exchanging information between refineries and technical departments. The following phases of maintenance are covered, summarizing the programs carried out in each instance; lubrication, pumps and drivers, compressors, cathodic protection, and non-metallic linings for large vessels. The training program includes both operator and craft training the former in the correct use of equipment and the latter in skilled maintenance.

1.2.2, 8.4.3, 4.6.9, 5.8.1

Control of Sour Crude Corrosion in Kansas Production Operations. L. C. CASE. Paper presented at the Seventh Annual Conf., Natl. Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 11, 390-396 (1951) Nov.

The corrosive portion of the Kansas oil fields covers generally all the area west of the Shoestring oil fields in the eastern part of the state. Within this area, the corrosion occurs mainly in wells producing from the Arbuckle limestone. Also, where serious corrosion occurs, there are certain common characteristics in chemical nature of well fluids and in the volumes of these fluids produced. In general, the brine is rather dilute, containing varying amounts of H_2S and CO_2 . Release of acid gases from the produced brine brings about rise in pH and deposition of scale in surface equipment and in disposal wells. The oil also contains acid gases and has poor wetting ability. However, as a general rule, subsurface corrosion does not become particularly troublesome until water is about 85 percent of produced fluid. Relative importance of corrosion, as judged by equipment costs is, in descending order: tubing interior, rods, pump, casing exterior, tubing exterior and casing interior. Tabulation of subsurface costs, due to corrosion, indicate that an over-all average would be near \$1800 per well year. The two most popular methods of corrosion control consists of down-hole introduction of oil wetting agents of formaldehyde. Comparison of before and after treating data indicates that these methods

accomplish closely similar savings in equipment repair, and costs of treating are also roughly equal. Testing costs average in the neighborhood of \$120 per well year and corrosion is lessened by approximately 50 percent. The present corrosion prevention practice in Kansas has resulted from many years' experimentation with resistant materials and methods of well treatment. Experimental resistant materials have included plastic tubing, various alloy rods and tubing, galvanized tubing, plastic-coated and cement-lined tubing. Treating methods have included exclusion of possible oxygen, neutralization agents and protective scale in addition to the formaldehyde and oil wetting agents. A few materials, which probably should be classed as coating compounds, have received limited testing in laboratory and field. Their further development seems a distinct possibility.

1.3. 5.9.4

Packaging Notebook. VII. Metal Drums. *Chem. Eng.*, 57, 239-240 (1950) Nov.

Describes and illustrates fabrication of the above, for use in transportation and storage of miscellaneous liquid chemicals. Outlines ICC specifications. Research program of Steel Shipping Container Institute of Battelle Memorial Institute on linings for the drums is outlined.—BLR.

1.3 Reviews

1.3. 5.4.1, 5.5.1

Coatings. T. G. ROCHOW AND R. W. STAFFORD. American Cyanamid Co. *Anal. Chem.*, 21, 196-202 (1949) Feb.

A critical review of the literature (c. 1935-1947) on the analysis of coatings covers methods for the determination of high polymeric materials, oils, pigments and waxes; some specific methods for individual components of coating materials are included such as polyhydric alcohols, aldehydes, dibasic acids, fatty acids and rubber compounding ingredients. Most papers referred to are data-free general discussions. 108 references.

1.7 Organized Studies

1.7.1, 4.3.3

Stress Corrosion Cracking in Alkaline Solutions—TP-5C—Sub-Surface Corrosion by Alkaline Solutions. A Technical Practices Committee Report, Nat'l Assoc. Corrosion Engrs. Publ. 51-3. H. W. SCHMIDT, P. J. GEGNER, G. HEINEMANN, C. F. POGACAR, AND E. H. WYCHE. Paper, NACE 7th Ann. Conf., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 9, 295-302 (1951) Sept.

A discussion is presented of the results of an industry survey on the failure of materials in alkaline solutions. Most of the data have to do with sodium hydroxide. The relationship of temperature and concentration to cause failure can be expressed only in an approximate manner. Corrective measures that have been employed to eliminate failure are discussed.

1.7.1, 7.7, 8.2.1, 8.2.2

Objectives of TP-16—Electrolysis and Corrosion of Cable Sheaths. IRWIN C. DIETZE. *Corrosion*, 7, No. 8, 253-255 (1951) Aug.

Scope of this technical committee, one

of the technical committees of the National Association of Corrosion Engineers, is given as to collect, investigate and develop data on electrolysis and corrosion of lead and other types of cable sheaths and make this information available to all members concerned. The six subcommittees are: TP-16A—Electrolysis and Corrosion of Cable Sheaths, TP-16B—Corrosion of Lead and Other Metallic Sheaths, TP-16C—Cathodic Protection of Cable Sheaths, TP-16D—Tests and Surveys, TP-16E—Corrosion and Protection of Pipe Type Cables, TP-16F—Non-Metallic Sheath Coatings. Names of committeemen and their addresses are given.

1.7.1, 1.1

NACE—A Virile Vehicle for An Organized Attack on Corrosion. NORTON E. BERRY, President National Association of Corrosion Engineers. *Corrosion*, 7, No. 9, 283 (1951) Sept.

Mr. Berry says the destructive effects of corrosion were recognized long before much was done about it. The purpose of the National Association of Corrosion Engineers is to promote and accelerate the benefits resulting from corrosion control.

1.7.1

Forum on Corrosion Research. Office of Naval Research. U. S. Dept. of Navy. Office of Naval Research, Washington, D. C., 79 pp. Gratis (TA-467, N-32).

Digests are presented of 16 papers covering electrochemical fundamentals, passivity and inhibitor studies, corrosion mechanisms and kinetics and high temperature corrosion studies presented at the National Academy of Sciences Nov. 9-10, 1949.

2. TESTING

2.2 On Location Tests

2.2.1, 2.3.2

A Survey of the Literature on Exposure Tests. J. W. BOON. Central Inst. for Testing Materials (Holland), Corrosion Committee IVb. Circular 1. Oct. 1950. 15 Figs. 47 pp. (in Dutch).

Six chapters deal with the following subjects; the composition of metallic coatings; the determination of the most important properties of zinc coatings; chemical treatments of metallic coatings and aluminum surfaces; a survey of exposure tests of steel protected by metallic coatings; a summary of conclusions to be drawn from the tests; and finally some observations on accelerated laboratory tests. The final pages of the circular contain over 100 references to the literature. Chapter 4, which contains the survey of exposure tests carried out in England and the U.S.A., covers 14 pages and summarizes the results obtained at each site.—ZDA.

2.2.2, 1.3

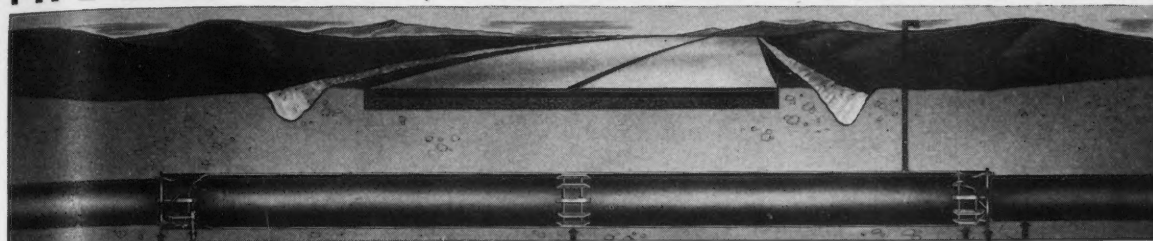
ASTM Exposure Test Site Program. *ASTM Bull.*, No. 169, 5-9 (1950) Oct.

Atmospheric exposure tests by ASTM corrosion committees from 1910 to the present are reviewed. The present 7 new sites selected are described and the 19 companies contributing monetarily to the new program are listed.

2.2.3, 2.3.4, 8.10.3

Corrosion of Steel in Sulfur-Producing Tubes, Frasch Process. D. A. SHOCK AND

PIPE-LINE TESTED, PROVED and ACCEPTED in '51



TYPE "L" CASING BUSHING

CONCENTRIC SUPPORT INSULATOR

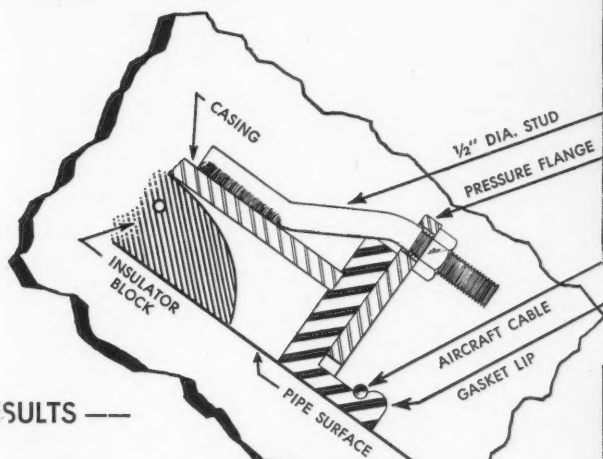
INSULATOR

CARRIER PIPE

TYPE "L" BUSHING

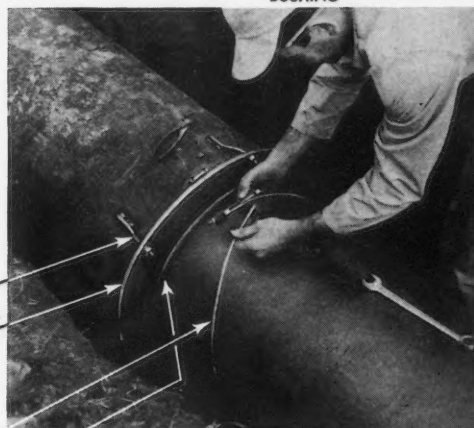
TYPE "L" Wm SEAL CASING BUSHING*

A New Design: It BUTTS Against End of Casing Instead of Fitting Inside the Casing.



RESULTS —

1. Easier to Install CORRECTLY under worst conditions of • Out-Of-Round Casing • Narrow Space Between Pipe & Casing • Wide Variations in Casing Wall and Coating Thickness • Mud • Casing ends beveled — by machine or hand torch.
2. WATER-TIGHT Seal with "L" gasket
 - BUTTED AGAINST CASING as pressure flange is tightened on 1/2" studs welded to casing.
 - TIGHT TO THE PIPE as aircraft cable (4,600# tensile) is tightened to gasket lip. Union is rubber covered to INSULATE galvanized cable assembly from bare casing structure.
3. Always Insulated from the pipe line when a Concentric-Support Insulator is installed just inside casing after the "drag section" is in place.



Assembling cable with rubber-covered union for clamping gasket lip to pipe.



THE COMPLETED INSTALLATION
Note that galvanized cable and union are insulated from pressure flange and from pipe.

AS STRONG & DEPENDABLE AS THE MEN WHO INSTALL THEM
REPRESENTATIVES

Stuart Steel Protection Corp. | R. E. Davis | James S. Kone Co. | Keyes Tank Co. | Keyes Tank & Supply Co. | Canadian Equipment Sales & Service Co., Ltd.
Kenilworth, N. J. | Los Angeles 15, Calif. | Amarillo, Texas | Provo, Utah | Casper, Wyoming | Edmonton, Calgary, Toronto, Canada

WRITE FOR BULLETIN 249A

T. D. Williamson, Inc.

TULSA 9, OKLAHOMA

8,000 Pipe Line Casings installed in 1951 with Williamson Bushings and Insulators.

N. HACKERMAN, Paper, A. C. S., 114th Meet., St. Louis, Sept. 6-10, 1949. *Ind. and Eng. Chem.*, 41, 1974-1977 (1949) Sept.

A container of corrosion test coupons was exposed in the flow lines of a Frasch process sulfur mining well. The corrosion rate was negligible in the presence of sulfur alone but increased tremendously during water-contacting periods in the presence of sulfur. The conclusions from the field tests were verified by laboratory tests in a simple bomb reactor.

2.2.4, 2.4.3, 8.4.3

Drill-Pipe Protection. W. H. CRENSHAW, V. B. BOTTOMS, C. N. WALLACE, AND C. R. O'DELL. *Oil Gas J.*, 48, No. 20, 262, 264-5 (1949) Sept. 22.

Service failures in drill pipe have been reduced by the use of drill collars to keep the pipe in tension and decrease bending stresses, a separate string for salt zones, smaller-diameter pipe to provide a more flexible string, reduced rotation speed, field inspection of pipe, e.g., by magnetic powder or internal optical techniques and protective measures, e.g., chemical inhibitors, plastic coating and shot-peening. Some physical properties of phenolic and vinyl plastic coatings are listed.

2.2.4, 2.4.3

Tubing Leak Tests. R. SNEDDON. *Petroleum Engr.*, 21, No. 2, B62, B64, B66, B68 (1949) Feb.

Tubing leaks may be determined easily by the use of a portable high pressure pump and a hydraulic make-up and break-out device that completes a test of each tubing stand in 90 seconds and gives visible evidence of any leaks, whether they are accompanied by reduction in wall thickness or not. The system is applied when the well is being pulled anyway. A plug is put in the top of each stand as it is broken and then as it is put back into the well, it is temporarily jointed up to an adapter on the hydraulic tester table, which does its own making and breaking, and the stand is subjected to a water test at any desired pressure up to 5000 psi. The method developed by the C & C Corp. can be used even where corrosion or wax accumulation have altered the circularity of the tubing interior. The test may be used to check the tubing string in the hole by employing a retrievable plug and suitable top and bottom packer assembly. The results of 204 tests gave an average of 16.4 leaks per string tested, with the collar leaks amounting to 77 percent of the total.

2.2.5, 4.5.3, 8.9.3

Techniques of Determining and Preventing Electrolytic Corrosion. R. L. WHITE, Quaker State Oil Refining Co. *Producer's Monthly*, 13, No. 8, 25-26 (1949) Aug.

Two techniques for determining electrolytic corrosion are described. In the first, the perpendicular method, the equipment consists of two long plastic tubes with a porous wooden plug in one end of each tube, both filled with a saturated copper sulfate solution. The tubes are placed in holes in the ground, a high resistance volt meter is connected across their terminals, and readings taken on both sides of the pipe every fifty feet; this length of interval seems to detect most anodic areas, since these are generally over one hundred feet long. In

the second test, known as a pipe-to-soil survey, a steel rod is substituted for the copper sulfate-filled tubes; this rod is driven down to make contact with the pipe. The copper sulfate tube is placed in contact with the ground over the pipe, and a reading taken by a volt-meter which is connected to the two electrodes. By the use of a long lead wire, readings are taken at 50-foot intervals along the pipe. A pipe-to-soil survey can be run in about one-fourth the time required for a perpendicular survey.

2.2.5, 2.4.4, 8.9.3

Technical Factors in Testing Pipe-Line Coatings. D. E. STEARNS, M. W. BELSON AND R. H. LEE. Paper, NACE 5th. Ann. Conf., Cincinnati, Ohio, April 11-14, 1949. *Corrosion*, 5, 342-346 (1949) Oct.

The minimum voltage at which adequate inspection of pipe-line coatings may be made is determined by the mechanics of applying the coating and by its thickness. Because of the conductivity of the ionized air and the material surface, there is negligible potential drop at distances up to 1/2 inch away from the point of the impressed voltage. In the use of holiday detectors, this means that good inspections do not require dc voltage nor the use of an electrode that covers a large area. As the detectors move along, each voltage picked up from an ac wave, or from a pulse wave, inspects a fairly wide band around the pipe at nearly even voltage. The generator should deliver a voltage close to the minimum necessary for adequate inspection. Three systems of generating voltage to a testing electrode are discussed.

2.3 Laboratory Methods

2.3.2

Corrosion Resistance of Pipe Measured. *World Oil*, 129, No. 8, 120 (1949) Nov.

The corrosion resistance of drill pipe sections under simulated severe oil field service in the presence of salt based mud is measured at the National Tube Co. laboratories. Brine is circulated through a pipe section which is rotated at up to 1000 r.p.m. in a spinning machine. A spring loading of up to 1,200,000 inch pounds is applied at the unattached end of the section. The steel section is thus alternately compressed and stretched at each point in its circumference. The rotating and flexing of a bowed drill pipe or one running in a crooked hole is thus simulated.

2.3.2, 2.3.5

Electrochemical Evaluation of Organic Coatings for Food-Container Tinplate Closures. W. K. SCHNEIDER, D. L. MCCONAUGHY, AND G. W. SEAGREN. *Food Technol.*, 3, 192-195 (1949).

An accelerated testing procedure was developed for predicting the failure of enamelled tinplate closures for glass containers. The procedure consisted of sealing the enamelled side of a piece of the tinplate to a cylinder with wax, a second piece being similarly sealed to the opposite end of the cylinder. The two pieces of tinplate were then connected to a 2-V. battery. The degree of corrosion was determined by estimating the amount of loosening of the enamel at the cathode and the number of pits at the anode test sample. When the bond between the

coating and the iron metal surface was destroyed by the alkaline products of the cathode reaction so that the coating was loosened, the rate of corrosion at the anode increased.—MA.

2.3.2, 7.1

Moisture Corrosion Tests for 2-105B Gear Lubricants. T. P. SANDS. Monsanto, Preprint, SAE National Fuels and Lubricants Meeting, St. Louis, Mo., Nov. 3-4 (1949) 4 pp. + charts \$0.25.

Moisture corrosion tests for hypoid gear lubricants are reviewed from the first beaker corrosion test described in Federal Spec. V. V.-L. 761. A modified beaker corrosion test was carried over into Army Spec. 2-105B in addition to an engine test with a standard Chevrolet passenger car hypoid unit. This unit, however, showed a lack of reproducibility. The Almen Pin Moisture test is also considered, but test results are influenced by many variables which must be controlled to obtain reproducibility. In a series of tests it was discovered that the correlation between the Almen pin test and field service was not good. Further work on the reproducibility of this test is urged as is an investigation of what level of moisture corrosion protection is required of hypoid gear lubricants to maintain satisfactory protection without a compromise on other desirable properties of the lubricant.

2.3.3, 4.6.12, 4.6.6

Modern Non-Corrosive Bactericidal Treatment of Input Water. F. LATTE. *Producers Monthly*, 13, No. 6, 47-9 (1949) April.

Laboratory and field tests have shown Pur-O-San (composition not given) to be a powerful bactericide, destroying the micro-organisms of raw water thereby preventing the plugging of the sand face by such organisms and also reducing corrosion by removing dissolved oxygen. The product increases the water intake rates, is non-toxic, non-irritating to the skin and safe for human consumption in the concentrations used in flood water and acts as a powerful wetting agent. Field test results are tabulated.

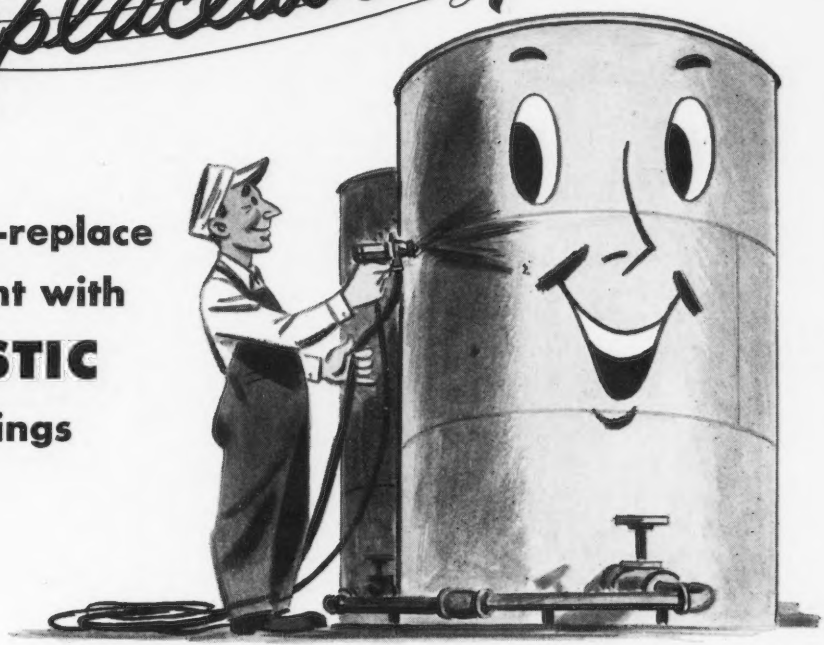
2.3.4, 6.4.2

New Method for the Colouroscopic Detection of Corrosion on Aluminium Surfaces. G. BACSKAI AND K. KOVACS. *Magyar Kem. Lapja* (Hungary) 4, 532-535 (1949).

The color reaction of aluminum with hematoxylin serves as a basis for the new method. A 10 percent aqueous gelatin solution is prepared, 1 percent ammonium chloride is added as an electrolyte and stabilizer, then a small portion of the solution is treated with hydrogen peroxide. After oxidation this portion is mixed with the unoxidized gelatin solution and 1 percent of a 10 percent solution of hematoxylin in ethyl alcohol is added. This reagent turns brown when treated in a water bath. The aluminum surface about to be examined is carefully freed from traces of grease and covered with a thin film of the gelatin solution with a brush or a spray. The corroded spots become deep violet in color in 0.5-3.0 minutes. This is clearly visibility through the brownish gelatin film. Final result can be observed 10 minutes after applying the gelatin films. Experiments proved that this method is more sensitive than that of Goldowsky. Some anti-corrosion agents may form colored compounds with hematoxylin. Aluminum surfaces treated previously with such

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Metal Equipment with
INSUL-MASTIC
Protective Coatings



You can help the scrap drive by collecting scrap, but not by *creating* it. So keep acids, alkalis and moisture from making scrap of your metal vessels and equipment . . . Coat them with INSUL-MASTIC *superior* coatings.

INSUL-MASTIC is the original Gilsonite coating. The one which proved the great resistance of Gilsonite to chemical attack. INSUL-MASTIC's binder contains 50% of this nearly inert mineral. Other coatings contain about 5% . . . or just enough to mention.

This is only one of the marks of *superior* quality which has made INSUL-MASTIC the leader among coatings. The very high percentage of mica flake is another one. Mica flake helps to give INSUL-MASTIC *superior* coatings their exceptionally long life. And when you specify a coating, you want *long life*.

Another quality of INSUL-MASTIC is homogenization. This prevents the Gilsonite, mica and other ingredients from separating. When we spray INSUL-MASTIC you can be sure that no filler has settled to the bottom of the drum. We apply what you specify.

When writing your coating specifications remember it will pay you to give utmost protection to your vessels and equipment by choosing the leader among coatings. Specify INSUL-MASTIC by name.

Think first of the coatings that last!

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agents should be tested before applying this method.—ALL.

2.3.5, 5.4.5, 7.2, 8.9.3

A Proposed Alternative Method for Measuring the Electrical Resistance of Pipe Line Coatings. J. K. BALLOU, R. P. HOWELL, J. W. LILJEBERG AND P. F. OFFERMANN. Standard Oil Company of California. *Corrosion*, 7, No. 12, 438-440 (1951) Dec.

Attenuation methods presented have been found to give results only a few percent from values obtained from averaging current-voltage relationships in determining the electrical resistance of pipe line coatings on buried pipe lines. A method is given of determining resistance by the attenuation method and derivation of the equations is given. A means of correcting results obtained for better values for a poor coating in high resistivity soils is outlined.

2.3.5, 5.4.5

Electrochemical Studies of Inhibitive Pigments. L. J. WALDRON. Naval Research Lab., Report 3547, Sept. 20, 1949, 24 pp.

This report covers the results obtained from electrochemical studies of selected pigments and the mechanism by which they may protect steel in the presence of electrolytes. The work involved potential and polarization tests with steel in solutions containing pigments in dissolved and suspended states and as pastes. Known soluble inhibitors were included for comparison. Potential tests gave qualitative information on the electrochemical effects of the more soluble inhibitors but failed to indicate whether such behavior was exhibited by the much less soluble pigments. Polarization studies gave quantitative information on the electrochemical behavior of suspended pigments when differential cells were employed. Red lead, zinc, tetroxochromate, chromated red lead, basic lead sulfate and blue lead were found to inhibit the corrosion of steel by increased polarization in both sulfate and chloride solutions. Iron oxide and mica pigment showed no inhibition while ferrous ammonium phosphate accelerated the corrosion of steel. The mechanism of such effects is explained on the basis of polarization of local cell elements. Tables and graphs are included. 37 references.—INCO.

2.3.7, 4.6.9, 3.5.11

Corrosion and Passivation of Mild Steel at High Speeds of Movement in Aqueous Solutions. F. WORMWELL AND H. C. K. ISON. Gt. Brit. Dept. of Scientific and Industrial Research, Chemical Research Laboratory, Teddington, Eng. *Chemistry & Industry* (London), No. 27, 549-550 (1950) July 8.

The phenomenon of protective film formation on mild steel in rapidly moving fresh water can be demonstrated with a rotar apparatus and distilled water or water of medium hardness moving at speeds of 750 and 1500 rpm. Specimens are unattacked for 7 days provided rotation is continuous. A period of stationary exposure at any stage in the test induces corrosion that is restricted when rotation is continued. Even at 200 rpm, only small rust spots and a brown film are produced.

Passivation of machined or emiered mild steel has also been demonstrated in 0.15 percent sodium chloride moving at 1000 or 1500 rpm. A favorable combination of circumstances presumably arises occasionally which permits the initial re-

pair of the oxide film on the steel under the conditions of rapid oxygen replenishment at the high speeds employed. The film once formed may be maintained for a time by the repairing action of the oxygen in solution. When breakdown occurs, however, it is doubtful that the film can be re-formed, but high anodic polarization may limit the corrosion rate at the restricted areas of breakdown. In about two hundred high-speed tests in the sodium chloride solution, passivation that began at the outset and that was maintained for more than one day occurred ten times. Corrosion commenced later at the edges and at isolated spots, but after seven days the weight losses were only about one-third (60-150 mg per sq. in.) that of the majority of the specimens.

For emiered steel samples immersed in rapidly moving 0.1 percent sodium chloride, the variation between tests is much less if the mean weight losses are compared during the first two days rather than after seven days. This divergence in corrosion rates is apparently connected with the extent to which rust is thrown off the specimen by rapid movement through the solution. The variations in rust adhesion appear to involve chiefly the ferric layer, although the physical condition of the underlying ferrous-ferric layer may also be affected. These variations in adhesion appear to influence the corrosion rate more than variation in surface preparation, in method of degreasing, in salt concentration, in speed from 500 to 1500 rpm, or in temperature in the range $25 \pm 1^\circ \text{C}$.

In service conditions it is unlikely that passivity will long persist in the presence of chloride, but the wide variation in corrosion rates at high speeds of movement may explain why exceptionally rapid pitting is occasionally observed on ship hulls.—PDA.

2.3.9, 2.4.3, 8.4.3

Mobile Units Used to X-Ray Field Equipment and Piping. *Petroleum Refiner*, 28, No. 10, 151 (1949) Oct.

Mobile radiography units used by M. W. Kellogg Co. to x-ray field fabricated equipment and piping are pictured. Each trailer includes dark-room equipment, examination space, refrigerating and water-storage units and space for storing radiography units in transit.

2.3.9, 7.5.5

Magnaflux Inspection of Welded Storage Tanks. F. A. UPSON. Standard Oil Co. (Ind.). Paper, Am. Welding Soc. Meeting, Chicago, Ill., Oct. 17-21, 1949.

The magnetic particle inspection method (Magnaflux) has been found suitable for the routing inspection of injurious defects in welded tank seams during two years of actual field experience. Details of the technique used vary with differences in tank size, plate thickness, welding and erection procedure, seam details and available Magnaflux equipment. Magnafluxing need not interfere with erection progress and can reveal serious defects that might otherwise remain undiscovered.

2.3.9, 3.6.5

A Polarographic Method for the Continuous Determination of the Consumption of Oxygen in Corrosion Tests. PAUL DELAHAY. *Corrosion*, 7, No. 5, 146-150 (1951) May.

The corroding solution flows at a constant rate in a cell containing the speci-

men. The concentration of oxygen at the outlet of the cell is measured by the polarographic method. Continuous recording of the oxygen concentration is possible. The calculation of the rate of oxygen consumption is presented together with examples. Corrosion tests in distilled water are possible as well as tests in mixtures of two dissolved gases. The various factors which may cause the rate of oxygen consumption to differ from the rate of corrosion are discussed. A method for computing the relative amounts of ferrous and ferric derivatives resulting from the corrosion of iron is presented.

2.3.9

Report of ASTM Committee E-7 on Non-Destructive Testing. *Proc. Am. Soc. Testing Materials*, 49, 520-521 (1949).

The activities of the committee, which are briefly reviewed, are chiefly concerned with radiographic inspection (e.g. of steel castings and steel welds) and ultrasonic testing.—MA.

2.3.9, 2.4.3, 7.2, 8.4.3

Nondestructive Testing of Drill Pipe. N. BOWERS. Gulf Oil Corp. Paper, Gulf Oil Corp. Prod. Eng. Conf., Pittsburgh, May, 1949. *World Oil*, 131, No. 1, 87-90 (1950) July 1.

Ten non-destructive tests in use today are electromagnetism induction, magnetic field, penetrating radiation, mechanical vibration, mechanical caliper, luminous energy, electric current conduction, electric field, thermal and pressure-leak and penetrant. Each is outlined briefly.

2.3.10

Preparation, Structure, and Applications of Thin Films of Silicon Monoxide and Titanium Dioxide. GEORG HASS. *J. Am. Ceramic Soc.*, 33, 353-360 (1950) Dec. 1.

Vacuum-deposited thin films of SiO decompose to silicon and silicon dioxide when heat-treated in an inert atmosphere and oxidize to silicon dioxide when heated in air. Their oxidation rates in air at various temperatures were measured by optical means. SiO is especially suitable for depositing protective layers on first-surface mirrors and for preparing replica and support films for electron-microscope and electron-diffraction studies. Titanium dioxide films prepared by evaporating titanium and oxidizing it in air at $400^\circ\text{--}500^\circ \text{C}$ have a rutile structure. Such rutile films can be used for splitting beams and for increasing the reflectivity of first-surface mirrors. 23 references.—BLR.

2.4 Instrumentation

2.4.2, 3.6.6

A New Instrument for Measuring Galvanic Corrosion Currents. H. P. GODARD. Department of Metallurgical Engineering and Fabricating Research Aluminium Laboratories, Ltd., Kingston, Ontario, Canada. Presented to the Protective Coatings Division at the annual meeting of the Chemical Institute of Canada, Toronto, June, 1950. *Corrosion*, 7, No. 3, 93-97 (1951) March.

The theory of galvanic corrosion is reviewed briefly.

An apparatus for measuring the magnitude of a galvanic corrosion current is shown schematically with a brief description of the theory of application and procedure. It consists briefly of a pair

TYGON

Versus
HF

"PROCEED with care" is sound advice wherever hydrofluoric acid is used or handled. This same advice also applies to the use of the versatile TYGON family of plastic compounds as protection against this highly corrosive acid. Properly used, TYGON does an excellent job of resisting HF in a range of concentrations and under a variety of conditions. Improperly used TYGON does not—cannot—give the maximum service possible.

The TYGON family consists of a series of polyvinyl resins carefully modified with other materials to give the ultimate in chemical resistance and physical properties. The many standard compounds available take the form of calendered or press-polished sheets, molded goods, extrusions, or protective coatings. Each form and each compound differs in its resistance to HF. Thus, to be effectively used, TYGON must be properly used.

In all exposures to hydrofluoric acid, TYGON may harden or discolor slightly, however, such minor changes do not affect protectability. In the case of TYGON sheeting, its resistance to hydrofluoric acid in concentrations up to 5% is excellent. Above 5% concentration, the resistance ranges from good to fair. Maximum service temperature for unprotected sheeting is 130°F. Above 130°F, an insulating sheathing consisting of carbon brick joined by a sulphur cement is recommended. With mixtures of HF and other chemicals, previous exposure tests or the counsel of U. S. Stoneware engineers is strongly advised.

TYGON sheeting finds use as a lining or covering for tanks, tank covers, diffusional towers, vats, bins, hoppers, troughs, blowers, impellers, fume hoods, and fume ducts. The sheets are also die-cut into gaskets, washers, and diaphragms for use in all types of process equipment.

When used as gasketing, TYGON resists all concentrations of HF at temperatures up to 130°F. This greater resistance results from only a relatively small area of the gasket being exposed. Higher service temperatures are possible, but depend upon the size, design, and specific use of the gasket.

As molded goods, TYGON takes the form of gaskets, grommets, washers, bumpers,

handles, closures, and miscellaneous parts and fittings. In these forms, the resistance to hydrofluoric acid approximates that of the sheeting. Once again, resistance to greater concentrations at higher temperatures is possible according to the size, design and intended use of the molded part.

As an extrusion, TYGON is primarily used as tubing or piping. However, extruded cord, channel, and tape also find use as gasketing, expansion jointing, packing or wrapping.

TYGON Tubing is widely used in the laboratory because of its clarity, flexibility, inertness, long life and ease of use. The larger sizes, up to 2" ID, are also becoming commonplace in the plant for use as flexible piping in acid transfer lines, as flexible connections, as inlet and outlet ports on pumps and filters, as syphon hoses, and as line desurgers.

In extruded form, TYGON resists hydrofluoric acid in concentrations up to 10% and at temperatures as high as 130°F. Above these limits or in exposures to HF mixed with other chemicals, the resistance varies and previous tests or the advice of qualified engineers is advised.

As a protective coating, TYGON is used in the form of a solvent type paint or as a plastisol (TYGOFLEX).

TYGON Paint is used to protect equipment, structural steel, walls, and ceilings, against the fumes and spillage of all concentrations of HF at temperatures up to 130°F. However, the limits of a thin film should be realized and only brief or intermittent contact is advised. Furthermore, any spillage should be immediately washed away.

TYGOFLEX is used as a heavy duty coating or in the casting or "slush" molding of intricate parts and fittings. Its resistance to HF depends on thickness of the coating, but usually is satisfactory against concentrations as high as 15% and temperatures up to 130°F.

Properly used, TYGON provides effective and economical protection against hydrofluoric acid. However, for maximum service, care in selection of form and compound, previous tests, and the advice of U. S. Stoneware engineers is recommended.

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of electrodes, a galvanometer connected across these electrodes, a dry cell, a variable resistor, an ammeter and two switches so connected so that the true short circuit current may be measured neglecting the measuring resistance. Also included are a simplified sketch of the final circuit and the balancing circuit, along with a photograph of the corrosion current apparatus.

A practical application for the use of this instrument in measuring the protection offered to the core of an aluminum alloy by the less noble cladding material is described.

Tables giving the alloy composition of the materials tested and the average readings are included. A graph of the galvanic current plotted as an ordinate versus the logarithm of the time plotted as an abscissa showed pure aluminum cladding offered substantially more protection than the alloy material.

A similar graph was plotted showing the effect of cathode/anode ratio on current density. The effect of cathode/anode ratio on galvanic current is illustrated on a plot on current versus cathode/anode area. The straight line relation indicates cathode control of the galvanic cell.

Several other practical problems have been served by the application of this instrument in the author's laboratory. Seven references are included.

2.4.2

Application of an Electrolytic Probe Technique to the Measurement of Corrosion Currents Underground. W. BECK. Paper, Electrochem. Soc. 96th Meet., Symposium on Corrosion, Inhibition and Passivation, Chicago, Oct. 12-15, 1949.

A probe consisting of an electrode of the same material as a buried structure was fastened to, but insulated from, the pipe surface and connected to the buried structure through a sensitive ammeter. The polarization characteristics of steel and lead electrodes were followed by measurements in tap water or moist soil. Stray current measurements were made on buried pipe and cable lines, using electrolytic probes as measuring electrodes. The currents emitted or picked up by the auxiliary electrodes were followed by a special oscillographic procedure.

2.5 Specifications and Standardization

2.5, 2.2.5, 5.4.5, 6.2.3

Conducting Exterior Exposure Tests of Paints on Steel. ASTM Specn. D1014-49T; ASTM Standards on Paint, Varnish, Lacquer & Related Products, 464-466, 1949.

Selection of test panels, hot-rolled structural steel angles, hot-rolled 1/4-inch plates and cold-rolled steel strip panels is discussed. Details of painting, exposure, examination and reporting are given.—RPI.

2.5, 2.3.4, 2.3.7, 5.4.5

Testing Bituminous Emulsions for Use as Protective Coatings for Metal. ASTM Specn. D1010-49T; ASTM Standards on Paint, Varnish, Lacquer & Related Products, 406-409, 1949.

Specifications are quoted for appearance, sampling methods, non-volatile content and carbon disulfide soluble non-volatile content, ash, water, etc. Performance tests cover wet flow, setting

characteristics, heat test (flow at 100 degrees C.), flexibility, water-resistance and resistance to breakdown by Portland cement.—RPI.

2.5, 2.3.1, 4.6.1

Report of Committee D-19 on Industrial Water. Am. Soc. Testing Materials Preprint No. 69, 34 pp. (1949).

The following tentative methods of test are proposed by ASTM Committee D-19 on Industrial Water: 1) Sampling Steam; 2) Acidity and Alkalinity in Industrial Water; 3) Solids in Industrial Waters; 4) Iron in Industrial Water. Revised standard methods of test are proposed for chloride ion and for sulfate ion in industrial water.

2.5, 2.2.5, 5.4.5, 6.6.11

Conducting Exterior Exposure Tests of Paints on Wood. ASTM Specn. D1006-49T; ASTM Standards on Paint, Varnish, Lacquer and Related Products, 458-463, 1949.

Exposure tests are carried out on composite panels at least 4 square feet in area, consisting of standard 5 1/2-inch feather-edged fence boards lapped horizontally and nailed to a back support. Two or three different types of wood are used in each panel, e.g., western red cedar and white pine. Full details of stand construction, painting and examination are given.—RPI.

2.5, 2.3.2, 5.4.5

Accelerated Weathering of Pitches and Asphalts. W. F. FAIR, JR., H. R. BECK AND B. K. MCKEE. Symposium on Accelerated Durability Testing of Bituminous Materials, ASTM Spec. Tech. Pub., 1949, No. 94, 84-99.

The conclusions of Strieter and Snoke concerning the formation of water-soluble products from asphalt by the action of ultra violet, heat, and air are confirmed. Water-soluble materials are extractable only to a small extent from pitches exposed to the above factors. Exposure of asphalts and pitches causes increases in softening points; addition of filler to pitches reduces this softening point rise. Pitches show no change in rate of dissolving in water during exposure; asphalts show considerable solubility for the first few 5-week periods and show a decrease thereafter. Accelerated ageing tests do not duplicate long-time service performances.—RPI.

3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2, 1.7.1, 4.4.2, 5.3.2, 8.4.3

High Pressure Sweet Oil Well Corrosion. H. L. BILHARTZ. Paper presented at the Seventh Annual Conference and Exhibition. Nat. Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 8, 256-264 (1951) Aug.

Severe tubing corrosion was recently encountered in high pressure sweet oil wells which were thought by all previously established criteria of judgment to be normal, non-corrosive installations. The evidence presented by an ever-increasing number of tubing failures provided sufficient justification for extensive study of the problem. Individual companies began private investigations. In addition, cooperative efforts among engineers of several companies introduced

historical data necessary during early phases of investigation. Subsequently, the National Association of Corrosion Engineers' Corrosion Committee TP-1C undertook the problem as its major project for study. This paper presents the results of statistical studies conducted under the auspices of the NACE committee, as well as basic data established during individual company investigations.

General pitting-type corrosion resulting from carbon dioxide, organic acids and possibly other unidentified corrosive agents occurs frequently in wells producing pipe line oil. The attack continues after wells begin producing water.

Pitting frequency varies with deviations in wall thickness of the tubing. Maximum concentration occurs at points of minimum wall thickness.

Unique and unexplained scale conditions have been observed which obscure the interpretation of tubing caliper surveys. Other popular criteria of corrosion are also difficult of interpretation.

Most known remedial measures have been tried. Inhibitors have proved unsuccessful; galvanizing has been of no value; thermosetting plastic coated tubing, with exceptions, has been promising. Nine percent nickel alloyed steel seems to afford a solution where work-over costs are exceptionally high. Nickel plated steel although as yet untried in the field, theoretically seems to offer advantages.

An economic analysis indicates ample justification for further study. It is shown by specific calculation that \$1,500,000 must be spent within the next four years because of corrosion in 150 wells concentrated in a small geographic area located in Southeastern Louisiana.

3.2.2

Influence of Hydrogen on the Cohesion of Steel. P. BASTIEN AND P. AZOU. Henry Brucher, Translation 2625, 3 pages. Translation available from Henry Brucher, P. O. Box 157, Altadena, Calif. From *Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences*, 228, 1651-1653 (1949) May 23.

Previously abstracted from original.—BLR.

3.2.2, 3.5.9

Reversible Hydrogen Brittleness of Iron and Steel at Low Temperatures. P. BASTIEN AND AZOU. *Compt. rend.*, 229, No. 119, 549-551. (1949).

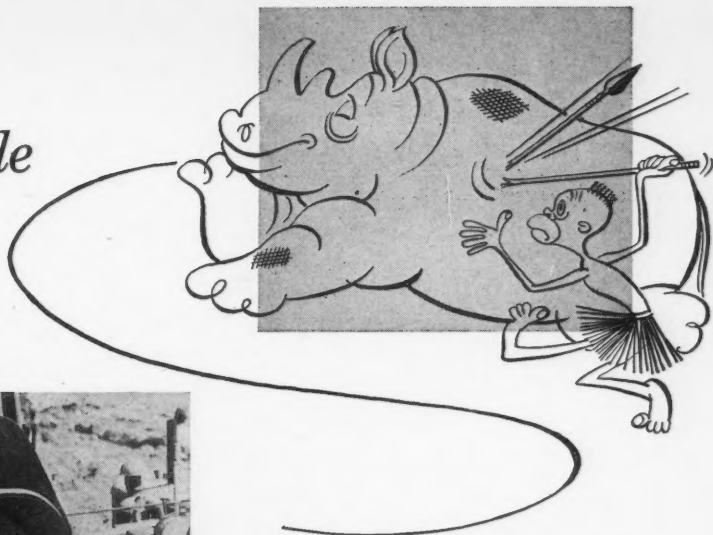
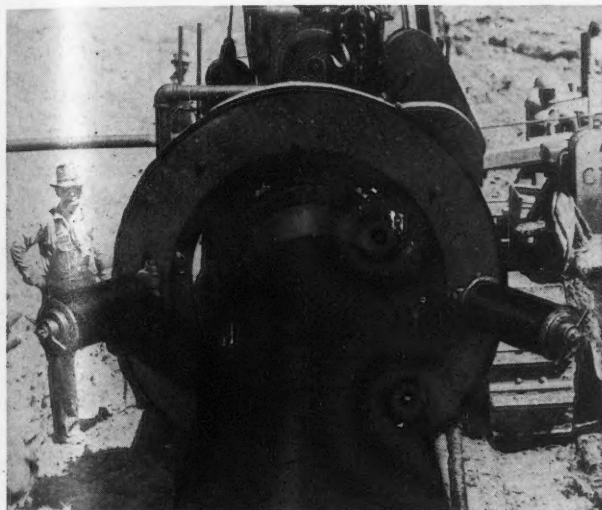
Discovery of the existence of a distinct reversibility of brittleness induced in steel by hydrogen. Temperature range within which this reversible brittleness manifests itself and the author's explanation of phenomenon are given. Cold working as a factor secondary to hydrogen pressures and triaxial stresses is discussed.—INCO.

3.2.2, 6.2.5, 3.7.3

The Mechanism of Knife-Line Attack in Welded Type 347 Stainless Steel. M. L. HOLZWORTH, F. H. BECK AND M. G. FONTANA. Ohio State University. *Corrosion*, 7, No. 12, 441-449 (1951) Dec.

Recent failures because of knife-line attack occurred in welded Type 347 stainless steel drums handling fuming nitric acid. Knife-line attack is intergranular corrosion in a narrow band adjacent to the weld. This attack occurs under specific conditions. The mechanism is based on the solid solubility of niobium (columbium) in 18-8 stain-

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less steels at high temperatures with subsequent formation of grain boundary chromium carbide during the sensitizing treatment. This type of corrosion was observed in fuming nitric acid and also in boiling 65 percent nitric acid. Experiments were conducted on regular Type 347 and Extra Low Carbon Type 347 stainless steels. The latter appeared to be less susceptible to knife-line attack.

3.2.2, 6.2.5

Statistical Study of the Resistance to Corrosion of 18% Cr, 8% Ni Steel in Acid Copper Sulfate. (In French.) J. BLETON, J. BLANOT, AND P. BASTIEN. *Soudure et Techniques Connexes*, 4, Nov.-Dec. 1950, p. 261-262.

The charts compiled permit immediate prediction of the sensitivity to intergranular corrosion of castings, on the basis of their carbon and chromium contents.—BLR.

3.3 Biological Effects

3.3.2

Relation Between Water Currents and the Intensity of Marine Borer and Foul- ing Attacks. H. DOOCHIN. *University of Miami, Marine Lab., Tech., Rep.*, 1949, No. 1, 17 pp.

The peak growth of most barnacles occurred at flow rates of about 0.2 knots; the limiting velocity for the attachment of organisms varied from 0.8-1.8 knots with the species.—RPI.

3.4 Chemical Effects

3.4.6, 6.2.4, 6.2.5

The Influence of the Curie Point on the Corrosion Rate of Chromium Steel in an Oxygen Atmosphere. R. J. SCULLY. B. S. Thesis, Dept. of Chem. Eng., M.I.T. (1949) 34 pp.

The corrosion rates of samples of chromium steels were investigated in the temperature ranges near the Curie points by exposing samples to an atmosphere of pure oxygen at various temperatures. Oxidation rates above and below the Curie point show a marked discontinuity at this point, indicating that corrosion rate is affected by the electron configuration of the metal. The rate of change of logarithm of corrosion rate with temperature versus percentage chromium passes through a maximum value at 12.2 percent. 10 references.

3.5 Physical and Mechanical Effects

3.5.8, 2.3.7

Stress Corrosion: Its Relation to Other Types of Corrosion. U. R. EVANS. Department of Metallurgy, Cambridge University, Pembroke Street, Cambridge, England. *Corrosion*, 7, No. 7, 238-244 (1951) July.

Corrosion damage can be classified into: 1) General (unlocalized) corrosion, 2) Pitting, 3) General intergranular corrosion, 4) Stress corrosion, 5) Corrosion fatigue. Of these, the first causes least weakening, while the last two cause the most weakening. Stress corrosion differs from corrosion fatigue in requiring pre-existing paths of weakness (generally

but not always intergranular); thus it occurs only on some materials after certain heat-treatments. Corrosion fatigue which manufactures its own disarrayed material as the crack proceeds can be obtained on almost any material exposed to alternating stresses in a corrosive environment. Preventative measures are briefly surveyed.

3.5.9, 2.3.5

The Effect of Thermal Gradients on the Corrosion Rate. O. F. NOSS, JR. B. S. Thesis. Dept. of Chem. Eng., M.I.T. (1949) 43 pp.

A definite reproducible corrosion current was found between two steel electrodes, one at 100 degrees C. and the other at 25 degrees C., immersed in aerated 3 percent sodium chloride solution. The hot electrode was the anode. The results are attributed to an oxygen concentration cell becoming established between the two electrodes. The corrosion rate equivalent to the current is 0.306 inches per year, about six times that of steel in sea water. Some preliminary experiments with a similar cell using a ferrous sulfate solution electrolyte are also reported. The results are of interest with respect to the design and corrosion protection of heat exchangers, condensers and other systems involving a temperature differential in the presence of a corrosive liquid.

3.5.9, 3.5.3

Contribution to the Study of the Wear of Ladle Nozzles. S. DESCOVICH AND F. SAVIOLI. *Metallurgia Italiana*, 42, No. 8/9 309-311 (1950) Aug., Sept.

A theoretical investigation on the widening of nozzles during the pouring of steel. Bearing in mind that at melting temperature the refractory should be considered as a high viscosity liquid in contact with a stream of lower viscosity liquid, an equation is set down which studies the dragging action of a fluid stream in contact with a wall composed by a highly-viscous material having a viscosity varying with the distance of the surface of the refractory, forming low viscosity slag. A few practical examples confirm the theory.

3.6 Electrochemical Effects

3.6.2, 6.2.5

Area Effects in Crevice Corrosion. O. B. ELLIS AND F. L. LAQUE. *Corrosion*, 7, No. 11, 362-364 (1951) Nov.

Specimens of stainless steel were prepared to provide an experimental approximation of a crevice relatively small with reference to the area outside exposed to the corrosive. Test panels were exposed to running fresh sea water for 87 days.

Data secured confirmed the expectations the extent of attack within a crevice was proportional to the area of the freely exposed metal outside. This means greatest danger exists when a crevice is associated with a large area of freely exposed metal and that when area of metal outside a crevice approaches zero the extent of corrosion within a crevice also will approach zero and will be determined only by the access of the corrosive medium and oxygen to surfaces within crevice.

The mechanism of crevice corrosion

involving a metal ion concentration cell is substantially the reverse of that postulated in the experiment conducted.

4. CORROSIVE ENVIRONMENTS

4.2 Atmospheric

4.2.1, 5.4.2

Porcelain Enamel as a Corrosion Resistant Coating for Metals. G. H. MCINTYRE. Presented at the Fifth Annual Conf. Nat'l. Assoc. Corrosion Engrs., April 11-14, 1949, Cincinnati, Ohio. *Corrosion*, 7, No. 4, 118-123 (1951) April.

The use of porcelain enamel as a decorative finish is briefly discussed as contrasted to its more recent use as a corrosion resistant coating. The properties of different types of enamels are enumerated as regards methods of application and resistance to acid, weather, water, inorganic salts and other chemicals. Some specific applications for corrosion resistance are discussed which include hot water storage tanks, housings for airplane and tank engine exhaust systems, glass-lined pipe for natural gas containing hydrogen sulfide, chemical process equipment and street or advertising signs. Resistance to impact damage is also discussed.

4.2.1, 2.2.2

Effect of Specimen Shape on Corrosion in the Atmosphere. H. R. COPSON. *Corrosion*, 7, No. 10, 335-338 (1951) Oct.

It is well known that the corrosion rate of metals in the atmosphere varies with the pollution present. Industrial and marine locations are more corrosive than rural locations. It is axiomatic therefore that the corrosion rate increases with the amount of contamination actually coming in contact with the specimen. This is controlled not only by the degree of pollution present, but also by the shape and form of the specimen. The shape determines the amount of air-borne pollution which impinges on the specimen. As this increases or decreases the corrosion rate increases or decreases. While this seems obvious enough it has generally been overlooked in the published literature. The present paper calls attention to this fact and gives appropriate illustrations. One illustration compares plain and threaded bars, another compares wire and sheet specimens and a third involves insect screen.

4.3 Chemicals Organic

4.3.2, 7.5.5

The Corrosion Resistance of Various Stainless Steels in Aqueous Solutions in the Presence of Dowex No. 50 Resin. ARNOLD R. OLSEN. Oak Ridge National Laboratory. Sept. 15, 1950. 17 p. (ORNL-804).

Since many reactions involving ion-exchange resins take place in corrosive media, corrosion of the resin containers becomes a problem. Tests were made to determine the comparative corrosion resistance of stainless steel Types 304, 309, 316, 347, 410, and 430, when exposed to Dowex No. 50 resin saturated with distilled water, 6 molar nitric acid and 5 percent oxalic acid for 2- and 4-month periods. The results indicate that Type

304 and Type 347 be used for unwelded and welded containers, respectively. The penetration rate for these steels is less than 0.12 mil per year.—NSA.

4.3.2, 7.5.6, 6.6.7, 6.6.8

Hydrofluoric Acid. P. P. KENNEDY. Du Pont. Paper, A.C.S. 116th Meeting, Atlantic City, N. J., Sept. 20, 1949. *Chem. Eng. News*, 3569-70 (1949) Nov. 28.

The developing of safe shipping containers for liquid anhydrous hydrofluoric acid and its aqueous solutions of various concentrations is discussed. A butyl rubber lining, adhering to a butyl-neoprene compound carcass stock, gave a safe container for hydrofluoric acid of up to 65 percent strength.

4.4 Chemicals Inorganic

4.4.9, 6.2.3

Corrosion of Wet Steel by Hydrogen Sulfide—Air Mixtures. D. C. BOND AND G. A. MARSH. Paper, 5th Ann. Conf., Natl. Assoc. of Corrosion Engineers, Cincinnati, April 11-14, 1949, *Corrosion*, 6, 22-26 (1950) Jan.

Experimental evidence is presented which indicates that for mild steel the most corrosive hydrogen sulfide air mixture consists of about one percent hydrogen sulfide in water-saturated air. At hydrogen sulfide concentrations of about 10 percent, corrosion rate increases about 20 percent when the temperature increases from 70 degrees F. to 120 degrees F.

4.6 Water and Steam

4.6.2, 8.2.2, 3.4.7

Prevention of Corrosion and Metal Attack in the Steam Water Cycle of the Steam Power Plant. FREDERICK G. STRAUB AND HARRY D. ONGMAN. Chem. Engr. Dept. Univ. Ill., Urbana, Ill. Paper, 7th Ann. Conf. Natl. Assoc. Corrosion Engrs. New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 9, 312-315 (1951) Sept.

This paper covers the potential sources of iron and copper solubility in the pre-boiler cycle and the effect of these metals on the steel in the boiler. The results of studies conducted to determine the effect of pH in the cycle on the solubility of these metals are given. These include the effect of increasing the pH of the steam and feed water by means of the controlled addition of ammonia to the cycle. It is shown that by maintaining a pH of 9 in the feed water by use of ammonia the copper as well as the iron solubility has been reduced to very low values. Methods of adding and controlling the ammonia in the cycle are given. A discussion is given of the action of reducing chemicals in the boiler beyond their normal action on free oxygen. This covers the potential action of these reducing chemicals in reducing the iron and copper entering the boiler so that they will not come in contact with the boiler metal until they have been reduced and thus eliminate these metals as potential oxygen carriers.

4.6.9, 8.4.3, 1.2.6

Literature Survey on Corrosion in Neutral Un-aerated Oil Well Brines. H. R. CORSON. Paper, 7th Ann. Conf. Natl. Assoc. Corrosion Engrs. New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 4, 123-127 (1951) Apr.



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The causes of oil well subsurface corrosion have never been properly determined. It is known that water must be present and that most corrosive waters contain hydrogen sulfide, although not all sulfide waters are corrosive. Severe corrosion apparently takes place in some cases in neutral brines in the absence of oxygen. This statement seems paradoxical. To investigate it further, a literature survey was undertaken. The object was to delineate the problems involved and to throw as much light upon them as possible. The literature is discussed particularly with reference to corrosion by hydrogen evolution and by depolarization with oxygen or other agents. Other factors which might enter into the corrosion picture are included in the discussion.

4.6.12, 8.4.3

Corrosion and Chemical Testing of Waters for Subsurface Injection. Parts I, II, III. J. W. WATKINS. Bureau of Mines. *Producers Monthly*, 14, No. 4, 15-19 (1950) Feb.; No. 5, 30-31 (1950) Mar.; No. 6, 25-31 (1950) Apr.

I—This article describes in detail methods of corrosion tests and chemical analyses that have been used extensively and satisfactorily in a study of plants that condition various surface waters and brines used for water flooding, brine disposal, and reservoir pressure maintenance in Kansas, Oklahoma and North Texas. The tests and analyses described were adapted and designed to be used in the field for determining the relative corrosive and plugging tendencies of waters from various sources conditioned by different methods.

II—The method used to determine dissolved oxygen in water for subsurface injection consists of adding manganous sulfate and potassium iodide solutions to precipitate manganous hydroxide, which combines with any dissolved oxygen, acidifying the mixture and titrating for the liberated iodine. If hydrogen sulfide or other interfering substances are present, the sample is first treated with excess iodine solution and hydrogen sulfide solution.

III—Field methods are given for determining free carbon dioxide, hydrogen sulfide, pH of waters and brines, total and dissolved iron in water, alkalinity and carbonate stability, hardness, chlorides, residual chlorine and turbidity of waters used for water flooding. (20 references.)

4.6.12, 8.4.3

Tubing Repair in Water Input Wells. J. W. FERRY AND J. C. VAUGHN. Quaker State Oil Refg. Co. *World Oil*, 129, No. 6, 166-8 (1949) Sept.

A method for self-plugging holes which have corroded through tubing in water input wells comprises sending plugging agents (plastic bits, pieces of rubber, or lead wool) inbedded in a wad of bubble gum or crude paraffin down the tubing. The carrier moves along with the stream of water until the hole is encountered, whereupon it squeezes through the hole, carrying the plug along and seating it in the hole. This plug automatically increases pressure, which drives the plug farther into the hole, thus effecting a pressure seal. Since the carrier automatically follows the water having higher velocity, there is little chance of its by-passing the hole. Best results were obtained with paraffin carriers and rubber plugs.

4.6.13, 8.4.3

A Method of Conditioning of Refinery Effluent for Re-Use and Disposal. F. M. FAULCONER, D. L. McCANN AND H. L. BEDELL. Socony-Vacuum Oil Co. Preprint, API, 14th Mid-Year Meeting, Refg. Div., Houston, April 4-7, 1949, 7 pp.

A method of partial conditioning of petroleum-refinery effluent for re-use and disposal as applied in the operation of a skimming and cracking plant, involves collection, cold process-water treating and filtering to soften the water, to remove oil and solids and for the return of the water to the plant cooling system. In the recirculation of the water within the plant, a higher concentration of dissolved solids is permitted so that the total effluent which must be eliminated from the plant is reduced to a minimum. This effluent is finally treated to remove all evidence of oil and most of the other contaminants. The water has little odor, it generally has a good appearance and contributes no deleterious effects to the local surface-drainage streams. Flow diagrams of the wastewater treater and of the refinery-water system are included.

4.7 Molten Metals

4.7

Resistance to Attack by Liquid Metals. LE ROY R. KELMAN, WALTER D. WILKINSON, AND FRANK L. YAGGEE. *Metal Progress*, 58, 868-B (1950) Dec. From "Liquid Metals Handbook." Office of Naval Research Publication NAVEXOS P-733. Also ANL-4417 (1950) July.

A graphical presentation. Resistance of each solid metal or alloy is given at 300° and 600° C. Qualitative degree of resistance is shown for 16 liquid metals in contact with 30 solid metals at the two temperatures.

4.7, 3.5.8

Investigation of Materials for Use in a Heat Transfer System Containing Molten Lead Alloys. Progress Report No. 1; June 1, 1950, to July 31, 1950. O. CUTLER SHEPARD. Stanford University School of Mineral Sciences. July 31, 1950, 8 p. (ORO-20; Report No. VIII.)

Progress is reported briefly on investigations of the solubility of pure iron in pure lead at various temperatures, wetting of metals by liquid lead and bismuth, unstressed corrosion tests and revision of stress-rupture apparatus for operation at higher temperatures.—NSA.

4.7

Metallurgical Investigations Concerned with the Behavior of Materials in an Environment of Liquid Lead-Bismuth Alloy. R. C. GRASSI, D. W. BAINBRIDGE, AND R. O. ELLIOTT. University of California Institute of Engineering Research. Sept. 1950. 59 p. (NP-1881.)

Stress-rupture properties at 1000° F of five low alloy and stainless steels are presented for environments of helium, hydrogen and liquid lead-bismuth alloy of eutectic composition. Experiments designed to produce wetting of steels by liquid lead-bismuth are described. The methods include controlled atmospheres, electroplating and fluxing. The problem of wetting is discussed in relation to solution rate and equilibrium solution

determinations. Results of static type solutions tests at 1400° F are given.—NSA.

5. PREVENTIVE MEASURES

5.1 General

5.1.1.3

Prevention of Corrosion By Means Other Than Protective Coatings. F. L. LA QUE. International Nickel Co., Inc., New York. *Corrosion*, 6, No. 2, 72-78 (1950) Feb. *Canadian Metals and Metallurgical Industries*, 12, No. 8, 14 (1949) Aug.

An introductory paper prepared for Section Meetings: Mineral Resources 6 (c) on Conservation by Corrosion Control. United Nations Scientific Conference on the Conservation and Utilization of Resources, April 26, 1949. The author discusses the prevention of corrosion by the control of environments such as humidity control, deaeration and inhibitors. He discusses cathodic protection, design factors and the adjustments of composition as factors in preventing or arresting corrosion. 77 references to periodicals are given. A bibliography of seven books in English, three in German, one in Spanish and three in Russian is given.

5.2 Cathodic Protection

5.2.1, 8.9.3

Pipeline Corrosion Control With Cathodic Protection. K. D. WAHLQUIST. *World Oil*, 128, No. 10, 163-164 (1949) Feb. 1.

Cathodic protection of buried and submerged pipe lines is reviewed, and the various types of equipment employed are described briefly.

5.2.1, 1.7.1, 1.4

Cathodic Protection Technical Practices Bulletin III. Prepared by Correlating Committee on Cathodic Protection, Nat'l. Assoc. Corrosion Engrs. March 10, 1951. *Corrosion*, 7, No. 6, 202-209 (1951) June.

Last of a series of four bulletins on cathodic protection issued by the Correlating Committee on Cathodic Protection. This bulletin deals with: 1) Current Required for Cathodic Protection. 2) Location of Current Supply Points. 3) Available current sources. 4) Anodes and ground beds. 5) Cathodic protection coordination among operators of underground structures. 6) Mitigation of effects caused by stray cathodic protection currents. It contains also a cathodic protection bibliography and the names of committee members and representatives of committee members of the correlating committee. (Also issued as part of Report, Correlating Committee on Cathodic Protection which includes all four bulletins issued by the committee. National Association of Corrosion Engineers, Houston, Texas.)

5.2.2, 2.2.4, 2.3.8, 8.9.3

Internal and External Corrosion Experience in Shell's Products Pipe Lines. S. S. SMITH, W. J. CURRY AND E. H. BUSH. Paper presented at the Sixth Ann. Conf., Natl. Assoc. Corrosion Engrs., St. Louis, Mo., April 4-7, 1950. *Corrosion*, 7, No. 1, 20-27 (1951) Jan.

The paper is in two sections. The first section summarizes ten years of experience on two product lines operated by Shell Oil Company using alkaline aque-

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ous solution of sodium nitrite as an internal corrosion inhibitor. Figures show the short and long time effect of nitrite inhibition and reduction of cost by elimination of scraper operation and hay tank and strainer operation is discussed. This section includes a generalized statement of increase of capacity which can be expected from sodium nitrite inhibition.

The second section discusses the use of magnesium anodes as an external corrosion preventive on Shell's products pipe line from Wood River to Chicago. The line is now 26 years old and was 21 years old with a moderately high leak frequency when anode installations were instituted. In order to analyze the effects of anode installations, pilot plant experiments were conducted and the paper reports these pilot plant experiments and their results and the conclusions drawn therefrom. Included in this section of the paper are several sets of field tests conducted before anodes were installed after anodes were installed and over several years of life of anodes. Pictures and drawings support the conclusions drawn from pilot plant experiments and results of field tests and experience during the five years of experimental work on the line are summarized. The conclusions drawn from this section of the report are that proper field testing and installation of magnesium anodes can control destructive corrosion sufficiently to extend the useful life of uncoated pipe lines to approximately double their unprotected life.

5.2.2, 7.2, 8.8.1

Combating Corrosion in a Chemical Plant With Magnesium Anodes. OLIVER OSBORN. A paper presented at a meeting of South Central Region, Natl. Assoc. Corrosion Engrs., Dallas, Texas, October 3-4, 1949. *Corrosion*, 7, No. 1, 2-9 (1951) Jan.

Cathodic protection of steel and cast iron in a chemical plant is economically justified and feasible from an engineering point of view under certain conditions. Magnesium anodes are useful under conditions which are restrictive as to space and accessibility. Principal use of magnesium anodes for cathodic protection of portions of the Dow Chemical Company's Freeport, Texas, plant were in structures handling large volumes of sea water and brine both static and in motion. Studies indicate the cost of the remedial measures is much less than would be the cost of replacing structures corroded to destruction, even when considerations of uninterrupted service, loss of production from down time and other factors are disregarded. Experimental installations are being studied and new aspects of the possibilities are constantly being investigated.

5.2.3, 2.3.4, 4.6.3, 6.2.3

Current Requirements for the Cathodic Protection of Steel in Dilute Aqueous Solutions. G. R. KEHN, E. I. du Pont de Nemours & Co., Orange, Texas, and E. J. WILHELM, University of Notre Dame, Notre Dame, Ind. *Corrosion*, 7, No. 5, 156-160 (1951) May.

A laboratory method, based upon colorimetric analysis is described for finding the minimum current density required to cathodically protect steel against corrosion by water containing a small amount of dissolved salts. The minimum current densities determined by this method are compared with those obtained from a Britton curve for each of the two test solutions of sodium sulfate and sodium chloride. The significance of the mini-

mum current densities determined by these two methods is discussed.

5.3 Metallic Coatings

5.3.2, 7.6.1, 3.7.2

New Techniques for Lining Vessels for Protection Against Corrosion. G. C. CARPENTER. *Petroleum Processing*, 5, 21-25 (1950) Jan.

A series of experiments with methods for applying corrosion-resistant liners to refinery vessels resulted in the development of a new technique, stud-welding, which is to be further tested in the field. As a result of the experiments, plug welding was discontinued in practice and various types of strip welding are now used, depending on temperature and problem, it has been learned, in which conditions of the specific application are the most important factor.—GPC.

5.3.2, 4.3.1

New Method of Corrosion Protection of Metals in Electrolytes by Monatomic Films of a More Noble Metal. (In German). O. ERBACHER, W. HERR, M. EBERT, AND H. VON BABO. *Arch. Metallkunde*, 3, No. 12, 409-413 (1949) Dec.

A metal exposed to aqueous media can be protected against corrosion not only by less noble (electrochemically active) or more noble (mechanically active) protective coatings of polyatomic thickness, but also by continuous monatomic films of a suitable more noble metal deposited from solution.

This method requires only about 10^{-6} grams of protecting metal per sq. cm. of area to be protected but the concentration of the nobler metal ion is critical and necessitates careful control. The rate of supply of the more noble ions must be regulated so that it is slightly higher than the rate of solution of the less noble base metal; if the rate of supply is much higher, local galvanic cells may become active, furnishing current for the electrolytic solution of the deposited nobler metal. The proper equilibrium can be established by furnishing the protective metal ions in the form of a complex compound and adding a simple compound that contains the non-metal part of the complex and acts as a regulating agent.

Monoatomic films of copper applied by this method from solutions containing a tartratecuprate (II) ion and sodium potassium tartrate (Seignette salt) gave excellent corrosion protection for iron; similar films applied from solutions containing a cuprammonium ion and ammonium hydroxide gave good protection for zinc. The rather weak protection afforded nickel coated with monoatomic bismuth is explained by the incomplete protective film resulting from the low rate of supply of bismuth ions from a strong hydrochloric acid solution of chlorobismuthate (III) ions.

The test specimens were emery-polished, 8- by 8- by 0.5-mm metal sheets which revolved at 90 rpm in 1.5 ml of test solution at 20° C. Total immersed area was 1.38 sq. cm. Ion concentrations as low as 10^{-6} grams were measured accurately with the aid of radioactive isotopes of the deposited metals. At such low concentrations, interference in the electrochemical reaction by ion adsorption phenomena would have been easily detected.

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5.4 Non-Metallic Coatings and Paints

5.4.1

Organic Coatings for Metals. E. E. McSWEENEY. *Battelle Memorial Institute Plat-ing*, 35, 340-3 (1949) April.

In a general discussion, coatings are classified on the basis of the mechanism of film formation, such as by solidification, solvent evaporation, oxidation or polymerization. Examples of each type of coating, the methods by which they are applied as well as their respective advantages are discussed. The factors to be considered in selecting the plasticizers, solvents, pigments and primers and in the use of the coatings are examined.

5.4.2, 4.3.6

Yellowing of Greens by Handling. N. R. FISK. *Paint Technol.*, 14, No. 167, 486 (1949).

It is suggested that the yellowing which occurs when articles coated with chrome green paint are handled may be due not merely to wearing away of the blue surface layer (which results from the floating of the Prussian blue) but also to the destructive action of perspiration on this pigment.—RPI.

5.4.2, 5.4.5, 6.6.5

Concrete Sealed by Glass Cloth and Resin. J. DELMONTE. *Concrete*, 57, No. 6, 12, 45 (1949).

A method of coating concrete pipes, storage tanks, etc., comprises the application of alternate layers of air-drying furane resin and abrasion-resistant glass cloth. The initial fluidity of the resin permits penetration into the concrete, wetting of the aggregate surfaces and filling the interstices, so assuring maximum bonding efficiency on drying. Curing of the furane-resin film for at least 24 hours is necessary. This laminated resin-treated glass-cloth coating is very resistant to water, strong acids, alkalis in all concentrations and industrial solvents, e.g., alcohols, esters, ketones, chlorinated hydrocarbons, as well as to aviation fuel.—R.P.I.

5.4.2, 3.5.9

High-Temperature Ceramic Paints. D. G. BENNETT. P.B. 39677, Frames 8; Board of Trade, Tech. Inf. & Docs. Unit, ORR, 117/50.

Data on the progress made in the improvement and further development of refractory ceramic paints designed to suppress or reflect radiations and to protect metals from high temperatures.—R.P.I.

5.4.4, 8.9.1, 2.4.1

Fire-Resistant Finishes for Aircraft. J. A. JONES, R. V. NISWANDER. *ASTM Bulletin*, 58-59+, 1950 May.

Describes development of a testing apparatus by which a realistic comparison can be made of combustible materials under conditions simulating those of an actual fire. A refractory coating material has been developed which is considered to provide satisfactory protection for certain critical aircraft components. Paint-type coatings have been produced which puff when subjected to heat and fire and form an insulating foam. However, the protection afforded by these coatings is only marginal for aircraft applications. Test results indicate greater need for improvement in film character-

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istics than for improvement in fire protection.—BLR.

5.4.5

Plastics for Protective Coatings and Linings of Chemical Plant. E. E. HALLS. *Metallurgia*, 42, No. 254, 376-381 (1950).

The materials and methods of commercial applications are discussed.

5.4.5

Painting on Wet Surfaces. *Shipping World*, 123, 457 (1950) Dec. 6.

Hitherto it has been considered that painting on wet surfaces or on substances that contain or retain moisture was inadvisable if not altogether impossible. Chemists of a British firm have now succeeded in producing a wetting agent for addition to oil and bituminous paints. This product, known as "Aquapaint," repels water and, added to a paint in as small a proportion as one percent, permits its application and promotes its adhesion to wet surfaces, while also increasing its adhesion to dry surfaces. "Aquapaint" is supplied as a solution in white spirit which insures easy mixing and it does not unduly dilute the paint. An average proportion is one ounce Aquapaint to one gallon of paint. In this proportion the drying properties and the color of the paint are unaffected. It also facilitates the painting of non-porous surfaces such as glass or galvanized steel and reduces the risk of "stripping." Mixed with white spirit in a 1:10 proportion it makes an excellent primer and improves the penetration and adhesion of paint to damp or porous surfaces. Among the uses for paint treated with this additive is the painting of hulls of ships in dry dock or for wet steelwork and scaffolding.—TIME.

5.4.5

Anti-Corrosion Primer. *Chem. Eng.*, 58, No. 1, 163 (1951) Jan.

A moisture and corrosion resistant coating, Primer P-10, is recommended for anti-corrosion protection for all ferrous and aluminum surfaces, but is not recommended for phosphate treated, Bonderized or Alox-treated steel. It is claimed that the primer, when used with the A Series Prufcoat, provides a simple 2-step system for corrosion-proofing old or moist metal surfaces. Manufactured by Prufcoat Labs., Inc.—INCO.

5.4.5

Outside Exposures of Paint Undercoats on Wood, Defects After Three and Four Years. R. DOOPER AND F. J. HERMANN. *Centraal Instituut Voor Materiaal-onderzoek*, Circ., No. 54, 1-13 (1949).

Of the three oil media, those based on raw linseed oil are now slightly inferior to those based on raw linseed oil, boiled or bodied linseed oil, especially on the underside of the panels. The medium oil length alkyd is slightly superior to the short oil. There is no direct relation between the nature of the pigment and durability in the oil medium series, but lithopone tends to give the best results. Aluminum primers in the alkyd series, particularly the more highly pigmented are unsatisfactory, showing a tendency to peel off. Otherwise, variation of the pigment/medium ratio within the limits chosen has little influence. All oil-free primers are unsatisfactory.—RPI.

5.4.5, 5.5.3, 1.2.1

Annual Rust and Corrosion Loss. ROGERS CLARK. *Sheet Metal Worker*, 40, 40-41+ (1949) Sept.

Describes the development of fish oil

as a primer coat to prevent corrosion.—BLR.

5.4.5

Silicones in the Protective Coating Industry. J. J. TYNER. *Finish*, 7, No. 2, 30-32 (1950).

The usefulness of silicone resins depends on their superior heat- and weather-resistance. Their solvent resistance is too low to make them useful for places where high solvent resistance is needed. The choice of pigment is important, especially for long shelf life.—RPI.

5.4.5, 4.3.1, 4.4.1

Corrosion-Resistant Plastic Coatings. *Chem. Eng.*, 57, 5, 198 (1950) May.

The first group of new plastic-base coatings, known as the V-200 series, is recommended for use over metal, wood, or concrete, wherever a simplified coating system is required to withstand the corrosive vapors present in chemical or processing plants. The V-200 coatings may be applied by spray, brush, or dipping. They can be air-dried quickly or baked to yield a flexible, abrasion-resistant coating highly adherent even to polished metal surfaces. Corrosion-inhibitive pigments within the system protect metals from under film corrosion. This gives the coating long life even when exposed to salt atmospheres, alcohols, soaps, fruit juices, acids, alkalis, petroleum products or related corrosives. Manufactured by Specialty Coatings Lab.—INCO.

5.4.5, 5.4.2

Metallic and Nonmetallic Coatings for Gray Iron. (Concluded.) CHARLES O. BURGESS. *Foundry*, 79, 108-111 (1951) Feb.

Discusses organic finishes, chemical conversion coatings, coloring and cement lining and armor. 20 references.

5.4.5

Wire Brushing No Longer Required for Painting of Rusty Roofs. CARLTON C. PORTER. *Am. Paint J.*, 35, 56-58 (1950) Dec. 25.

Outlines results of field tests which prove that one coat of zinc-pigment paint gives good protection against rust if loose scale is removed with a stiff brush from galvanized roofs.—BLR.

5.4.5, 7.2, 1.7.1

Report of the Dutch Corrosion Committee II For The Study of Soil Corrosion and Protection of Pipelines. Communication No. 25. Central Institute for Research on Materials. Corrosion Dept. (National Council for Industrial Research, Delft, Holland) Oct. 1948, 48 p. (TA-468, C-39).

Properties are given of blown asphaltic bitumen for the coating of steel pipes. Information is also included on the application of the blown asphalt bitumen for both internal and external protection. Specifications for the testing of coatings and a description of test methods are also given.

5.4.5

Preventing Corrosion With Protective Paint Coatings. GEORGE DIEHLMAN (Promotion Manager, Protective Coating Paints, National Lead Co., New York 6, N. Y.), AND E. L. BEENFELDT (Manager, Southern Division, National Lead Co., Los Angeles 23, Calif.) *Corrosion*, 7, No. 3, 88-92 (1951) March.

Red lead, the best known corrosion inhibitive pigment and the one with the longest record of successful performance, is used as the sole pigment or in combination with other pigments incor-

porated in a suitable binding medium or vehicle. It is used to keep the metal surface in a non-corroding or passive state.

To reduce painting costs, protective coatings should be carefully applied to a properly prepared surface. Factors to be considered in formulation and proper use of red lead paints are given, and for guidance of the maintenance engineer, a classification of red lead paints according to intended exposure conditions and a reference listing of current specifications useful as a procurement basis is included.

Factors governing performance of paint coatings are listed as: Nature of metal to be coated, surface preparation, intended environmental conditions and paints, primers, topcoats. Illustrations show results after exposure of several surface preparation methods and application schedules. Protective paint systems for principal exposures are recommended, and a guide for selection of the correct red lead paint keyed to environments is given in tabular form.

5.4.5, 3.3.2, 8.9.5

Anti-Fouling Agents Free from Metal for Paints for Ships Bottoms and Seaplane Floats. SCHONHOEFER. P. B. 4674, Microfilm Reels 1-4, Board of Trade, Tech. Inf. & Docs. Unit, FD, 1962/49.

Research is described to find copper and mercury free materials to use as anti-fouling agents. Substances of the "Gesarol" type and a resin based on o-chloro-toluene were found to be effective.—RPI.

5.4.5, 2.7

Some Causes of Paint Peeling. F. B. ROWLEY AND M. H. LA JOY. *Univ. of Minnesota, Eng. Expt. Station, Bull.*, 1949, No. 30, 39 pp.

A wood-sheathed test house with different types of heat-insulating materials on some walls and none on others was subjected to 70° F 60-65 percent relative humidity inside and 20°-32° F 70-80 percent relative humidity outside; moisture content of timber, blistering and peeling were followed for more than 60 days. Blistering occurred at 25-40 percent water content and peeling began first on non-insulated walls.—RPI.

5.4.5, 4.2.7

Evaluation of Silicone Coating for Wire-Wound Power Resistors. U. S. Naval Research Lab. Problem No. 32C0-21T (Buships Request No. 51493); Final Report 1949, 5.

Specimen resistors were tested in the NRL tropical chamber. Initially the coating had excellent properties and was not susceptible to moisture or fungus, but on weathering prohibitive mechanical failure of the film set in. Modifications to silicone formulation and to resistor design are suggested.—RPI.

5.4.5, 5.4.2

The Stearates in the Protective Coatings Industry. F. J. LICATA. *Am. Paint J.*, 33, No. 27, 55-6+ (1949) Mar. 28.

Metal stearates are used in the protective coating industry in the thickening, suspending and flattening of paints, varnishes, enamels, lacquers, sealers, stains, silk screen extender bases, cement water paints, waterproofing, paint removers and other applications. A brief description of the manufacture of the stearates is followed by a discussion of the properties and applications of calcium, lead, magnesium, zinc and aluminum stearates. Aluminum stearate combines with

a large number of solvents, oils, waxes and resins to form gels having varying structures, such as slightly viscous liquids, rigid, buttery gels or thixo-tropic pastes. The aromatic solvents, like toluene and benzene, are the best solvents for aluminum stearate; they form permanently elastic and transparent gels at 110° F. The aliphatic hydrocarbons form metastable elastic gels on heating to 180° F; these metastable gels become cloudy, buttery pastes on aging.

5.4.5, 6.2.2, 6.3.3

Painting Light-Gauge Steel and Wrought Iron. J. LAWRENCE. *J. Decorative Art*, 71, Pt. 842, 79-80 (1951).

Different painting schemes are proposed for light steel and wrought iron on delivery according to whether the erected units will be easily accessible for painting, and according to the kind of previous treatment. Detailed specifications are given for treatments to follow a) paint pre-treatment as described in *Review*, 1951, 87, b) metallizing, and c) bituminous paint. Specifications are given for painting steel window frames, phosphatized, metallized or untreated. 3- or 4-coat systems, based on chromate, red lead or zinc dust primers are recommended.—RPI.

5.4.5, 6.6.8

Plastic Coatings and Corrosion. C. G. MUNGER. *American Pipe and Construction Co. World Oil*, 128, No. 9, 176-7+ (1949) Jan.

Vinyl chloride and vinyl chloride copolymer groups of resins are considered in the light of their chemical and water-resistant properties and various phenomena of osmosis and electroendosmosis are evaluated in their effects on the success of corrosion-preventive coatings. The studies are of especial value in the protection of tubular goods and tank structures.

5.4.7

Modern Masking Materials and Methods for Fabrication and Spray Finishing. Part IV. Liquid Masking Materials and Peelable Plastic Coatings. A. P. SCHULZE. *Products Finishing*, 1950, 44-62, Nov.

For some spray finishing purposes, liquid masking materials applied by brush or spray offer advantages not found in pressure-sensitive tapes of metal masks. Materials of this nature are discussed as to their characteristics and applications in this final part of the article. Peelable plastic coatings are also applied by spraying to polished sheets which are to be former and drawn. The plastic film protects the sheet from die marks and can be peeled off the product after its fabrication. The third general use for liquid masking materials and peelable plastic coatings discussed in this article is that of coating paint-spray booth walls to facilitate periodic maintenance and cleaning operations. A number of products used for this purpose are described and discussed, and a number of references to the literature are cited.—TDD.

5.4.7

Steam Spray Method of Product Finishing. M. E. HERRING. *Am. Paint J.*, 35, No. 12, 83-84 (1950).

The use of a spray gun which operates on dry superheated steam in place of compressed air is described. A considerable saving is claimed, since lacquers of high solids content can be used. Thicker films with fewer pinholes are



Because increasing the degree of motion of a corroding solution brings more oxygen to the surface of the metal with which it is in contact, such increase has a decided influence on the rate of corrosion. In liquid that may appear quiet, convection currents are nonetheless at work slowly distributing dissolved oxygen throughout the solution. When velocity agitates the liquid-air interface, unsaturated liquid is brought to the surface layer and the oxygen-solution rate rapidly stepped up. At the same time the liquid film on the surface of the metal is thinned so that this increased amount of dissolved oxygen diffuses more readily. Thus the combined effect of more dissolved oxygen conveyed more rapidly to the metal is a marked acceleration of corrosion.

Velocity, too, is often the indirect if not the direct cause of mechanical erosion of metal, for the deterioration it helps bring about results in the formation of corrosion products. In a quiet system these might serve a protective function but with motion a factor they erode readily, leaving already weakened metal exposed to further corrosive attack.

The ever-varied interplay of its many governing factors render the mechanism of corrosion complex indeed. Recognizing effects, determining causes, and controlling those that can neither be eliminated nor regulated is a responsibility industry has long assigned to Dampney. The reduction of your corrosion problems through the medium of Dampney equipment-engineered protective coatings . . . formulations of vinyls, ceramics, asphaltums, silicones, chlorinated rubber and other natural and synthetic resins . . . is a responsibility we should likewise welcome.

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obtained than when compressed air is used.—RPI.

5.4.7, 6.2.1

New Blackening Bath for Ferrous Metals. A. F. HOLDEN. *Materials & Methods*, 33, 128-1 (1951) Jan.

Describes new bath for use with stainless steels, cast iron, or most steels. Offered under the trade name Perma-Black, it is finding use in blackening of ferrous metals for either increased corrosion resistance or nonreflectivity.—BLR.

5.4.7

Applications of Corrosion-Resistant Coatings. C. M. JEKOT. *Organic Finishing*, 11, No. 6, 14-17 (1950).

Coatings for metal tanks for storage of food, such as milk, syrups, oils and for chemicals, such as formaldehyde, acetic acid, mineral oil latex are usually based on phenolic or vinyl resins or chlorinated rubber. Degreasing the metal is often sufficient pretreatment, although sandblasting or pickling may be desirable or necessary in many cases.—RPI.

5.4.7

Red Lead—Spraying or Brushing. *Ind.-Lack.-Betrieb*, 18, No. 10, 190 (1950).

The difficulties and dangers of spraying red lead primers are discussed. Brushing is the more efficient method of application.—RPI.

5.4.7

Description and Instruction for Use of Plastic Paint Spray Equipment, Mare Island Type. U. S. Navy Department. Board of Trade, Tech. Inf. & Docs. Unit, ORR, 365/49, PB. 16083, 24 pp.

Mare Island plastic antifouling paint is hot sprayed in a coating 0.04" thick. It consists of toxins dispersed in a resinous base and is said to be effective for at least two years. The plastic is heated to 275° F and sprayed under a pressure of 90 lb. per in. using electrically heated hose and guns. A ship's bottom should be coated in an 8 hour shift; the ship should then be undocked immediately as the plastic may flow in hot sun. Details and illustrations of equipment and application methods are given.—RPI.

5.4.8

Protective Coatings for Underwater Steel Structures. A. W. VAN HEUCKEROOTH, R. W. HILL and G. S. COOK. Symposium on Varnish and Paint Chemistry, College of Engineering, New York University, 1948, pp. 41-50.

As a result of laboratory tests on 6 paint systems it was concluded that four coats of a paint pigmented with red iron oxide, zinc chromate and red lead gave best results for underwater exposure except under highly acid or alkaline conditions. Four coats of a zinc dust/zinc oxide paint gave satisfactory results in sea water or under intermittent exposure conditions.—ZDA.

5.4.8, 3.5.9, 5.4.5, 8.9.5

Hot Surface Marine Paint. H. L. WARNECKE. *Paint Oil Chem. Rev.*, 114, No. 8, 31-34 (1951) Apr. 12.

Marine engineers are well acquainted with the problem of painting hot surfaces. Boiler-fronts, furnace doors, tuyère pipes, breechings, steam condensers, etc., exposed to red or orange heat at times are a difficult painting problem. The United States Navy has a Specification (52 P 19) which requires a paint film to withstand 400° F, the next six days,

every day, 100° F more, until on the 7th day, 1000° F is reached. High heat paints are usually made in three temperature groups; for temperatures up to 500° F—most alkyls and colors will meet this requirement; for temperatures from 500° to 700° F this range is hardest to fit, as it is too high for most film formers and too low for metallic sintering action without a fluxing medium; and for temperatures above 700° F, which are not too hard to meet, unless outside application and weather resistance is required. In that case we again refer to the special coating, which in many cases may be the answer to the very difficult paint problem of painting steel and iron at elevated temperatures.—TDD.

5.4.8, 8.8.4

Chlorinated Rubber Coatings for Tan Pits. H. F. SARX. *Das Leder*, 1, 65 (1950); *Rubber Res. Abs.*, 28, No. 8, 608 (1950).

Because of their chemical resistance, chlorinated rubber paints are suitable for steelwork in tanneries; details are given of their application. Concrete may be protected from tanning liquors by chlorinated rubber/bitumen mixtures. In a discussion of the paper, speakers stated that tan pits lined with chlorinated rubber paint had been in use for up to 10 years.—RPI.

5.4.8, 6.6.5

Acidproof Coating. *Chem. Eng.*, 58, No. 1, 164 (1951) Jan.

Unskilled and inexpensive acidproofing of concrete floors, for many corrosive surfaces, is now possible with the use of a brush-on phenol-formaldehyde coating that hardens at room temperature. In addition to being easy to apply, the new material is 2-9 times harder than conventional floor paints. One primer coat and 2 finish coats are estimated to last 2-3 years on steps and other surfaces where considerable walking takes place. The new material is called Phenoline. Manufactured by Carbolite Co.—INCO.

5.4.8, 1.2.5, 8.10.4

Decontamination and Corrosion Resistance Properties of Selected Laboratory Surfaces. C. D. WATSON, T. H. HANDELY, and G. A. WEST. Oak Ridge National Laboratory. Aug. 29, 1950. Decl. Oct. 3, 1950. 35 p. (AECD-2996; ORNL-732).

A selection of 50 materials has been compared as decontaminable surfaces applicable to radiochemical laboratories. The susceptibility of these materials to contamination with a fission product mixture, their subsequent ease of decontamination with various reagent washes and resistance to common laboratory reagents are presented. A selection has been made of the best materials for each of the following applications: uncoated reference materials (for control purposes), baked interior panels, protective plastic coatings (air dried), laboratory bench top materials, floor tiles and disposable (strippable) plastic films.—NSA.

5.5 Oil and Grease Coatings

5.5.1, 2.3.2

A Symposium on the Testing of Temporary Corrosion Preventives. Inst. Petroleum Preprint, 82 pp. (1950) Obtainable from the Institute, 26 Portland Place, London, W.1. *Is. Jour. Inst. Petroleum*, 36, No. 320, 504-542 (1950).

A number of papers: The nature and scope of temporary protectives (D. Clay-

ton and M. C. Thompson, 1-6); various accelerated corrosion tests (T. G. Clinton 6-14; W. Pohl 14-27; T. P. Hoar and G. C. Smith 28-36; R. St. J. Preston and E. G. Stroud 37-42; and S. G. Clarke and E. E. Longhurst 42-53); aviation uses and tests (E. W. J. Mardles and J. Mason 53-65); American methods (C. F. McCue and E. R. Blane 66-73); and tests other than corrosion tests (H. Hollis 73-82). Both ferrous and non-ferrous basis materials are considered.—BNF.

5.6 Packaging

5.6.1, 7.7, 8.2.2, 4.2.7

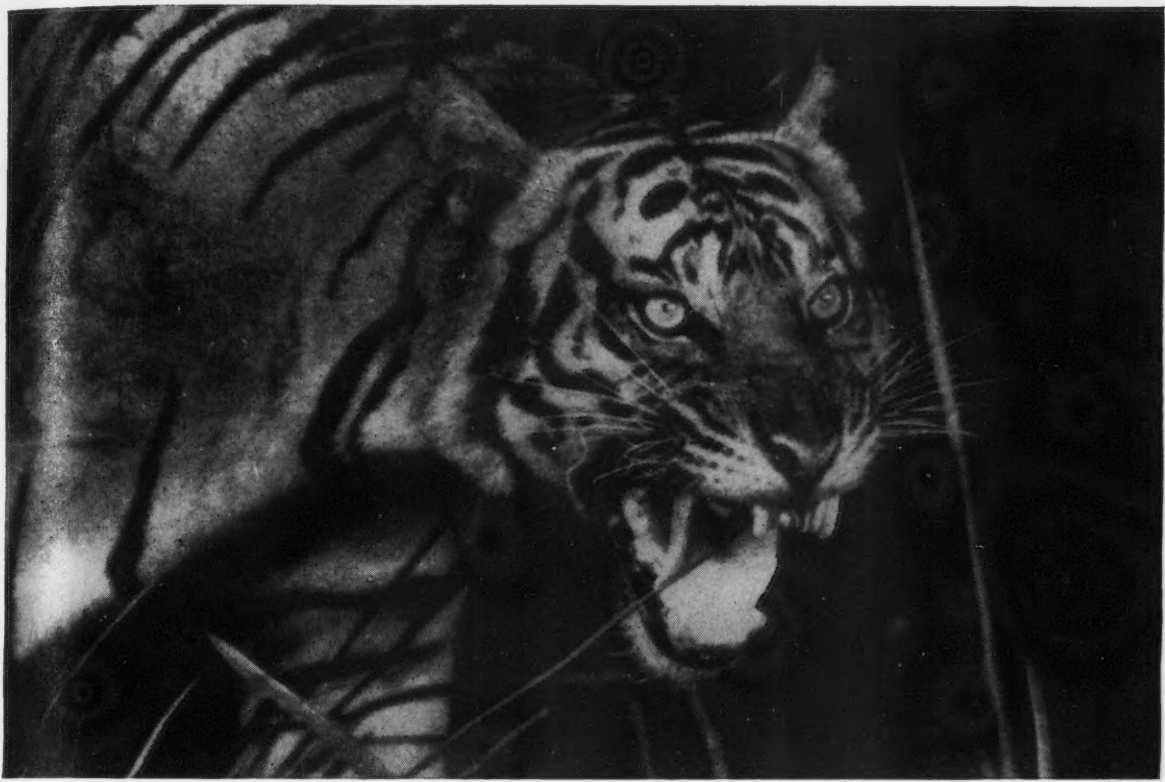
Effect of Packaging on Corrosion of Zinc Plated Equipment. K. G. COMPTON, S. M. ARNOLD and A. MENDIZZA. Paper presented, 7th Ann. Conf., Natl. Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 11, 365-372 (1951) Nov.

Packaging can sometimes be conducive to unexpected, and at times very unpleasant experiences, often resulting in loss of valuable equipment and time. Experience of a large company manufacturing electrical equipment is illustrative of problems that arise and which eventually led to a broad investigation of packaging and its effect on the corrosion of zinc plated equipment and apparatus.

An unexpected strike in the field necessitated storing large quantities of equipment for periods considerably in excess of that which was ordinarily the custom. The suddenness of this emergency compelled employment of storage facilities over and above those normally needed which in some cases were admittedly poor, but were the best available at the time. When work was resumed in the field it was discovered that appreciable quantities of equipment were very severely corroded, some requiring costly refinishing, others actual replacement. While the condition of the equipment was attributed to storage for considerable lengths of time during an exceptionally humid and hot time of the year, and in some instances under very poor storage conditions, it was felt that other factors, principally the type of packaging, were also contributory. When the corrosion of the stored equipment was first observed, it was noted that parts which had been packed in paper cartons were in better condition than were those in plywood boxes.

In view of the extensive damage and the possibility this contingency might recur it was deemed necessary to ascertain the cause or causes for this widespread corrosion and the reasons for differences in the degree of corrosion. A preliminary investigation was made in an attempt to duplicate in the laboratory the type and extent of corrosion encountered in the field. Encouraging results of these first tests led to an extension of the work. The purpose of the second and more comprehensive study was to determine what effect, if any, various packaging materials and methods of packing had on the rate of corrosion, what physical and/or chemical factors were controlling and what remedial measures were indicated in order to prevent, or minimize a repetition of this trouble. This investigation attempts to answer these questions and indicates the desirability of further work in order to clarify some of the questions not yet completely and satisfactorily answered.

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5.8 Inhibitors and Passivators

5.8.2, 7.5.5, 8.9.3

The Use of Ammonia in Control of Vapor Zone Corrosion of Storage Tanks. F. T. GARDNER, A. T. CLOTHIER (Carter Oil Co. Research Lab., Tulsa, Okla.) AND F. CORYELL (Interstate Oil Pipe Line Co., Tulsa, Okla.). Paper, South Central Regional Meeting, Nat'l. Assoc. Corrosion Engrs., Dallas, Texas, October 3-4, 1949 and at the Am. Petroleum Inst. Meeting in Chicago, Ill., November 7-10, 1949. *Corrosion*, 6, No. 2, 58-65 (1950) Feb.

Laboratory studies have shown that ammonia in concentrations as low as 0.4 percent in systems containing 2 percent hydrogen sulfide by volume is effective in controlling vapor zone corrosion. Results of experimental field work with 55,000-barrel tanks showed that the efficiency of protection gradually increased from 16 percent when an inhibitor injection rate of 1.4 pounds per tank per day was employed to almost complete protection when 12 to 15 pounds per day were added to the tank vapor zone. The uninhibited corrosion rate measured simultaneously in tanks in similar service averaged 273 mdd, or 0.053 ipy, for the entire test period.

The Interstate Oil Pipe Line Company is now using ammonia in treating eight tanks at three pipe line stations. Three tanks at Magnolia Station in Southern Arkansas and two at Moore Station in northern Louisiana are receiving ammonia from bulk storage. The three remaining tanks under treatment are at the Yellowstone Station near Billings, Montana. Ammonia usage is economical and is equally effective in both areas despite the great differences in climatic conditions. Previously published in whole or part in *Oil and Gas J.*, 48, No. 27, 238-246 (1949) Nov. 10 and *Petro. Eng.*, XXI, No. 12, D 18-20 (1949) Nov.

5.8.3, 3.6.8, 1.8

An Electrochemical Mechanism of Corrosion Inhibition by Chromates, Nitrites and Other Oxidants. MARCEL POURBAIX (University of Brussels, Belgium) AND PIERRE VAN RYSSSELBERGHE (University of Oregon. *Corrosion*, 6, No. 9, 313-315 (1950) Sept.

This article is based upon a communication at the discussion on inhibitors at the Gordon Research Conference on Corrosion at New London, New Hampshire, July, 1949, and constitutes a portion of a theoretical and experimental study of inhibitors based upon the use of the polarographic method. It classifies corrosion inhibitors as: 1) surface conversion inhibitors; 2) adsorption inhibitors; 3) diffusion inhibitors, with examples of each. A brief analysis of the mechanism of each type is given. The role of the inhibitor is defined in a discussion of corrosion of iron by a solution free of oxygen with inhibitor absent. This phenomenon is studied using polarization curves. A further discussion considers the corrosion reaction when a chromate or nitrite has been added. Minimum inhibitor concentration for protection is shown to be that which for a given oxygen concentration, brings the potential of the metal to a value corresponding to its passivation value. The electrochemical mechanism described shows that, at inhibitor concentrations insufficient for protection, both the inhibitor

and oxygen are consumed in reduction reactions. The authors are attempting to make direct polarographic determinations of inhibitor consumption.

5.8.3, 5.8.4

Effect of Sodium Chloride and Oxygen Concentrations on Sodium Nitrite Inhibition of Steel Corrosion. R. C. B. BERRY. Thesis. MIT M.S. Dept. Chem. Eng., 1949, 54 pp.

Experimental evidence is presented to show that nitrite inhibition is accomplished by nitrite absorption on the entire steel surface. Oxygen has a deleterious effect on nitrite inhibition. At inhibitor concentrations of 0.01 percent sodium nitrite is more effective than sodium chromate as an inhibitor in solutions containing up to 0.01 percent sodium chloride. At salt concentrations between 0.5 percent and 3.5 percent nitrite is less effective than chromate. At sodium chloride concentrations above 0.5 percent the main role of sodium nitrite is as a cathodic depolarizer and not an inhibitor. Inhibition by Calgon inhibitor is more complete in water containing calcium than in calcium-free water.

5.8.4

Shell VPI 260, A Powerful Corrosion Inhibitor. *Petroleum Times*, 53, 394 (1949) May 6.

Shell Petroleum Co. has developed a powerful corrosion inhibitor, Shell VPI 260, for preventing corrosion of iron and steel and other metals between manufacturing steps, in packages for shipment and during storage. The product is a white crystalline stable organic compound which sublimates very slowly. The vapor, which is odorless, non-toxic and non-injurious to the skin, completely surrounds any article in an enclosed space and prevents corrosion by moisture and air. Direct contact of the solid VPI with the metal is not required. VPI forms an invisible, thin protective film on the metal surface. Only a trace of VPI is required to make condensed water non-corrosive to a steel surface. VPI may be applied in solid powder form, dissolved in water or alcohol or by use of coated wrapping material.

5.8.4, 4.3.2, 2.3.4

Rosin Amine-Ethylene Oxide Condensates as Corrosion Inhibitors for Mild Steel in Hydrochloric Acid. EDWARD A. BRIED AND HARRY M. WINN. Paper presented, 7th Ann. Conf., Natl. Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 6, 180-185 (1951) June.

The use of inhibited acids, especially hydrochloric acid, in applications such as metal cleaning and oil well acidizing has increased considerably in recent years due to the development of effective corrosion inhibitors. Organic nitrogen compounds, particularly amines, have long been known to be effective as HCl inhibitors for steel presumably because of their ability to absorb on the metal surface, thus forming a protective layer.

The development of an amine derivative of rosin led to an evaluation of this product as an HCl inhibitor. Good results were obtained, but the relatively low solubility of rosin amine in hydrochloric acid imposed a concentration limitation. It was found that condensation of the amine with ethylene oxide formed oxyethylated amines which possessed good solubility in HCl and good corrosion inhibition. Even more impor-

tant were the discoveries that the oxyethylated amines would act as solubilizing agents for up to 15 percent of their weight of free amine and that addition of free amine to the oxyethylated amines improved their inhibitive properties.

The optimum ethylene oxide content was determined by evaluating a series of condensates containing from one to 31 moles ethylene oxide per mole of rosin amine. The 5-mole condensate was found to be optimum from the standpoint of both inhibition efficiency and acid solubility. The 5-mole condensate containing 15 percent free amine gave penetration values of 0.130 and 0.159 inch per year at concentrations of 0.20 and 0.05 percent as compared to about 17.0 inches per year for the controls. Test conditions involved mild steel in 15 percent HCl at 165 degree F. for four hours.

The 5-mole condensate containing 15 percent free amine was further evaluated at 0.20 percent concentration by varying both the acid concentration and contact time. Weight losses of mild steel in both inhibited and control acids were determined at 10 time intervals from eight to 240 minutes in 5, 10 and 15 percent HCl. Curves of corrosion rates plotted as a function of time show that in the uninhibited acids the rate increased rapidly for about 40 minutes, then increased slowly for the duration of the tests. In inhibited acids curves of corrosion as a function of time indicate a maximum rate at the shortest time intervals, and that the rate decreases logarithmically as a function of time. This is believed to be due to increased adsorption of the inhibitor during the course of the test.

5.8.4, 5.8.3, 6.2.3

Corrosion Inhibitors for Steel. W. G. PALMER. *J. Iron and Steel Inst. (British)* 1949, 421-431, Dec.; *Corrosion*, 7, No. 1, 10-19 (1951) Jan.

Many inhibitors, added to water or chloride solution in amounts insufficient to stop attack altogether, produce localized attack, which is more intense than the general corrosion met with in the absence of an inhibitor. Inhibitors which are free from this danger are, in most cases, inefficient. It is believed that the danger is connected with the formation of blister-like membranes over the sensitive points, which prevent the access of the inhibitor to those very points where it is required. By using suitable mixtures of phosphate and chromate (or phosphate and persulphate), so that any substance precipitated will not be ferrous phosphate but ferric phosphate (a crystalline non-membranous body), the danger can be avoided. Even if the mixture is added to an amount too small to stop corrosion altogether, no intensified corrosion or pitting is observed.

5.8.4, 5.8.2, 2.2.7, 2.3.4, 8.4.2

Field and Laboratory Tests of Sodium Chromates and Alkalies for Controlling Corrosion in Gas-Condensate Wells. C. K. EILERTS, R. V. SMITH, F. G. ARCHER, L. M. BURMAN, FAYE GREENE AND H. C. HAMONTRE. Petroleum and Natural Gas Branch, U. S. Department of the Interior, Bureau of Mines, Bartlesville, Okla. Presented at the Gas Industry Symposium of the Conference of Nat'l Assoc. Corrosion Engrs. in Cincinnati, Ohio, April 11, 1949. *Corrosion*, 6, No. 4, 131-136 (1950) April.

The results of investigations of the Bureau of Mines begun in 1944 have indicated that chromates are effective and economical inhibitors for controlling corrosion in gas-condensate wells. Rates

of corrosion in the flowstring can be reduced to negligible values by maintaining low concentrations of the inhibitor in the water phase of the flowing fluid. The chromates are not equally serviceable in all wells and fields, and the principal problem of their use is one of preventing chemical reduction to insoluble hydrous chromic oxide which may be deposited on the walls of the tubing and obstruct flow. Maintaining a high pH in the flowstream by injecting alkalis with the chromates and avoiding high concentrations of the chromates in the flowstream are effective methods of minimizing the reduction of chromates by substances that occur in some reservoir fluids. Costs of chemical treatment in two gas-condensate fields indicated that corrosion protection by means of sodium chromates and alkalis adds less than \$1.00 to the expense of producing a million cubic feet of gas.

5.9 Surface Treatment

5.9.1

Preparing Metal Surfaces for Painting. Ministry of Works, Advisory leaflet, 1950, No. 11, 3 pp.

Practical methods for the preparation of surfaces for painting are described with special reference to metals commonly used in building, e.g., iron, steel, aluminum, zinc, copper and lead. General rules for the treatment of dirty, corroded and smooth metal surfaces are given. The removal of mill scale from iron and steel and the careful choice of primers is stressed.—RPI.

5.9.1, 2.3.4

Metal Cleaning Problems and Tests for Cleaners. ADOLPH BREGMAN. *Metal Progress*, 57, 339-340+ (1950) Mar.

A previous article briefly discussed the main types of cleaning methods. This article deals more specifically with some of the cleaning methods and surveys numerous tests used for evaluating the effectiveness of cleaners.—BLR.

5.9.2

Development of Metal Cleaners Using Radioisotopic Evaluation Methods. J. C. HARRIS AND R. E. KAMP. *Metal Finishing*, 48, No. 11, 75-78 (1950).

The radioisotopic tracer method for determination of soil removal combined with a dilution technique proved suitable for the evaluation of combinations of various surface active agents and alkalis.

A relatively non-foaming composition consisting of 2.5 percent Sterox C.D. and 97.5 percent sodium metasilicate performed at least as satisfactorily as the better known lathering composition of 5 percent alkyl benzene sulphonate, 95 percent metasilicate composition. Of the various alkali types used (in combination with Santomerce No. 1) the meta- and orthosilicates proved most effective, a second but lower level of effectiveness was attained by soda ash, tri-sodium phosphate and tetrasodium pyrophosphate, while still lower in soil removal were modified soda and caustic soda.—EL.

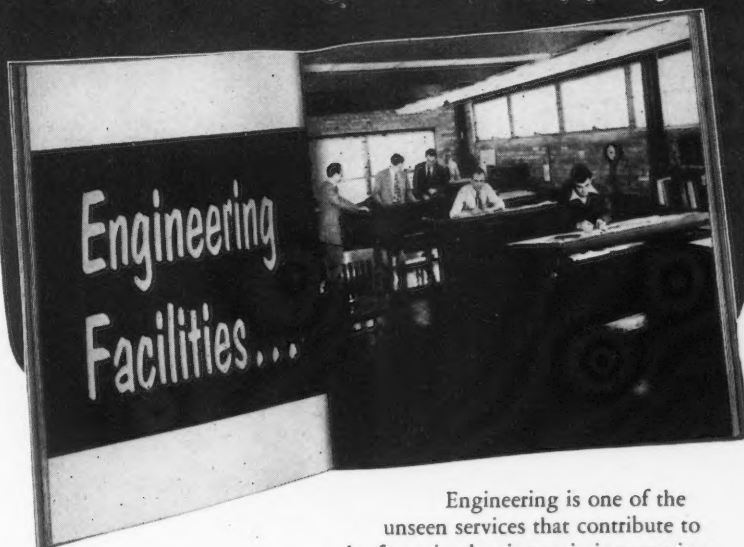
5.9.3

Abrasive Blasting Prepared Pipe Surfaces for Coating. J. F. FARRELL. *Petroleum Engr.*, 21, No. 11, D34-6 (1949) Oct.

Current practices in blast cleaning

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pipe, the relative advantages of air and airless blasts and the equipment used in blast cleaning pipe are described.

5.9.3, 7.2, 8.9.3

Preparation of Pipe Surface for Bitumen Coating During Reconditioning. O. C. MUND. Shell Pipe Line Corp., Houston, Texas. Paper delivered at the Fifth Annual Conference, Nat'l Assoc. of Corrosion Engrs., Cincinnati, Ohio, April 11-14, 1949. *Corrosion*, 6, No. 1, 19-21, discussion 21-22 (1950) Jan.

The exterior cleaning of pipe after removal from soil in the preparation for bitumen coating application is a major item of expense during reconditioning. Removal of all adhering material from the metal surface can be accomplished most practically by sandblasting or equivalent treatment. However such procedure is expensive and slow, especially when the line remains intact or in service. Most corrosion products and soil particles are inert in the absence of moisture and the retention of small amounts of such materials on the pipe surface, particularly when adherence is good, will not impair coating effectiveness if moisture is removed. Moisture can be removed by chemical treatment at a reasonable cost, thus reducing cleaning costs without impairing coating results. A solution of diluted pipe primer has been found effective in reducing moisture content of the residual foreign products on the pipe surface.

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.1, 4.3.6

Electrochemical and Chemical Corrosion. H. GRUBITSCH, E. VONTILAINEN and H. VAYRYNEN. *Werkstoffe u. Korrosion*, 1, No. 12, 477-481 (1950).

A short review of the corrosion characteristics of ferrous metals in neutral electrolytes.—EL.

6.2.2, 3.4.10, 4.3.5, 4.6.1, 2.3.4

Corrosion Studies of Iron in the Presence of Sulfur. RAYMOND B. SEYMOUR, WALTER R. PASCOE and R. D. STOUT. *Corrosion*, 7, No. 8, 265-268 (1951) Aug.

The authors give details of a study to determine effects of additives in sulfur cement and in surrounding aqueous solution when an interface of iron and sulfur was present in contact with water. No corrosion was observed when the iron was protected by even thin layers of sulfur cement. While information on corrosion at this interface was obtained it should not be misinterpreted insofar as performance of sulfur joints in cast iron pipe is concerned. Historical evidence and results of this study indicate properly prepared sulfur cement joints are satisfactory in bell and spigot cast iron water mains. The study consisted in partly or completely embedding an iron rod in a molten composition based on sulfur and immersing the resulting mass in water under various conditions.

The addition of sodium chloride to the sulfur cement accelerated corrosion of the iron at the sulfur iron interface. Completely embedded iron rods in a silica-filled sulfur cement were unaffected after two years' immersion in tap water, water at various conditions of pH and

in the presence of aqueous sodium chloride.

6.2.3, 5.8.4, 3.4.6

Diffusion of Hydrogen in Steels of Different Carbon Contents During Acid Etching. (In Russian.) S. A. BALEZIN AND D. YA. SOLOVEI. *Doklady Akademii Nauk SSSR* (Reports of the Academy of Sciences of the U.S.S.R.), new ser., 75, 811-814 (1950) Dec. 21.

Several pickling inhibitors, including thiourea, diethyl aniline, thiodiglycol, etc., were investigated in connection with the above for steels containing 0.14-1.20 percent carbon and nominal percentages of silicon, manganese, sulfur and phosphorus. Data are tabulated, charted and discussed.—BLR.

6.2.3, 4.4.7

The Corrosion of Mild Steel by the Products of Combustion of Gaseous Fuels. H. A. PRAY, R. S. PEOPLES, R. S. DALRYMPLE and R. S. AND C. T. SIMS. Project DGR-4-CH Rep. No. 2 to AGA Committee on Domestic Gas Research, Battelle Memorial Inst. Aug. 1949.

A description is given in the original of corrosion testing equipment developed for the testing of materials in the presence of flue gas under a variety of operating and temperature conditions. Corrosion rates were obtained for SAE 1020 steel at sulfur levels from 0 to 50 grains per 109 cubic feet of 1000 Btu. gas under conditions of continuous condensation and heating and cyclic operations where heating time was kept constant and the cooling period for each cycle varied. The corrosion rates are a function of the length of time at condensation conditions, whether the operation is continuous or cyclic. The rate of penetration decreases markedly as the time of exposure increases up to 100 to 200 hours until it reaches an essentially constant value.

6.2.3, 3.4.6, 5.8.4

Effect of Chloride and Oxygen Concentration on the Corrosion of Mild Steel With Chromate Inhibitor. C. McDONALD. Thesis M.I.T. M.S., Dept. Chem. Eng. 1949, 39 pp.

The corrosion rate of mild steel by solutions containing a fixed concentration of chloride was measured, using a solution saturated with air and with oxygen at one atmosphere. It was found that oxygen concentration has no effect on corrosion rate in chromate-inhibited distilled water. Increasing oxygen concentration accelerates corrosion where chloride is present in chromate solutions. Nitrite is a more effective inhibitor than chromate when used in the same weight concentration in dilute chloride solutions. Nitrite provides no protection at the higher chloride concentrations used, while chromate affords about the same protection as for the low chloride.

6.2.5, 3.5.9

Development and Current Trends in High-Temperature Wrought Steels. (Entwicklung und Stand der hitzebeständigen Walz- und Schmiedestähle.) K. BUNGARDT. *Stahl u. Eisen*, 71, No. 6, 273-283 (1951) Mar. 15.

The basis of all high temperature steels is iron-chromium, with other constituents added to produce one or more of especially desired properties. Silicon and aluminum improve scale resistance, nickel and manganese widen the γ -region and give rise to the formation of aus-

tenite which is of particular importance for good mechanical properties at high temperatures. The replacement and reduction in critical constituents during World War II was offset by a general return to prewar standards in the most recent years. Two groups dominate the current picture in wrought steel; annealable ferritic chromium-silicon, chromium-aluminum and chromium-aluminum-silicon steels and austenitic and austenitic-ferritic chromium nickel and chromium-manganese steels. The latter have, particularly in Germany, gained importance as substitutes for nickel-steels in temperature regions up to 900° C.

6.2.5, 1.3, 3.7.1

Physical Metallurgy of Austenitic Stainless Steels. HELMUT THIELSCH. *Welding J.*, 29, 577s-621s (1950) Dec.

Reviews present state of knowledge and results of recent research investigations on chromium-nickel stainless steels and their weldability. Emphasizes phase relations, corrosion resistance, crack sensitivity, stress-corrosion cracking and effects of cold deformation and of sub-zero and elevated temperatures. Numerous tables, graphs, phase diagrams, micrographs, macrographs, etc. 257 references.—BLR.

6.2.5, 3.8.4, 2.3.3

Effect of Magnetic Transformation at the Curie Temperatures on Oxidation Rates of Chromium-Iron Alloys. H. H. UHLIG AND A. DE S. BRASUNAS. M.I.T. Paper before Electrochem. Soc., Buffalo, Oct. 11-13, 1950. *J. Electrochem. Soc.*, 97, No. 12, 448-452 (1950) Dec.

Oxidation rates of chromium-iron alloys containing 9.2-24 chromium were carried out in oxygen at temperatures above and below the Curie temperatures. Plots of the logarithms of the oxidation rates with the reciprocal absolute temperatures show discontinuities at the Curie temperatures. In general, activation energies calculated from the oxidation rate data are higher above the Curie temperatures than below. The data lend support to the view that rate of formation of thin films is controlled by reaction phenomena at the metal-oxide-interface. Rideal and Jones showed earlier that the rate-controlling step may involve transfer of electrons from the metal. Therefore, a higher work function for the metal above than below the Curie temperatures may be associated with the observed trend of activation energy. 18 references.—INCO.

6.2.5

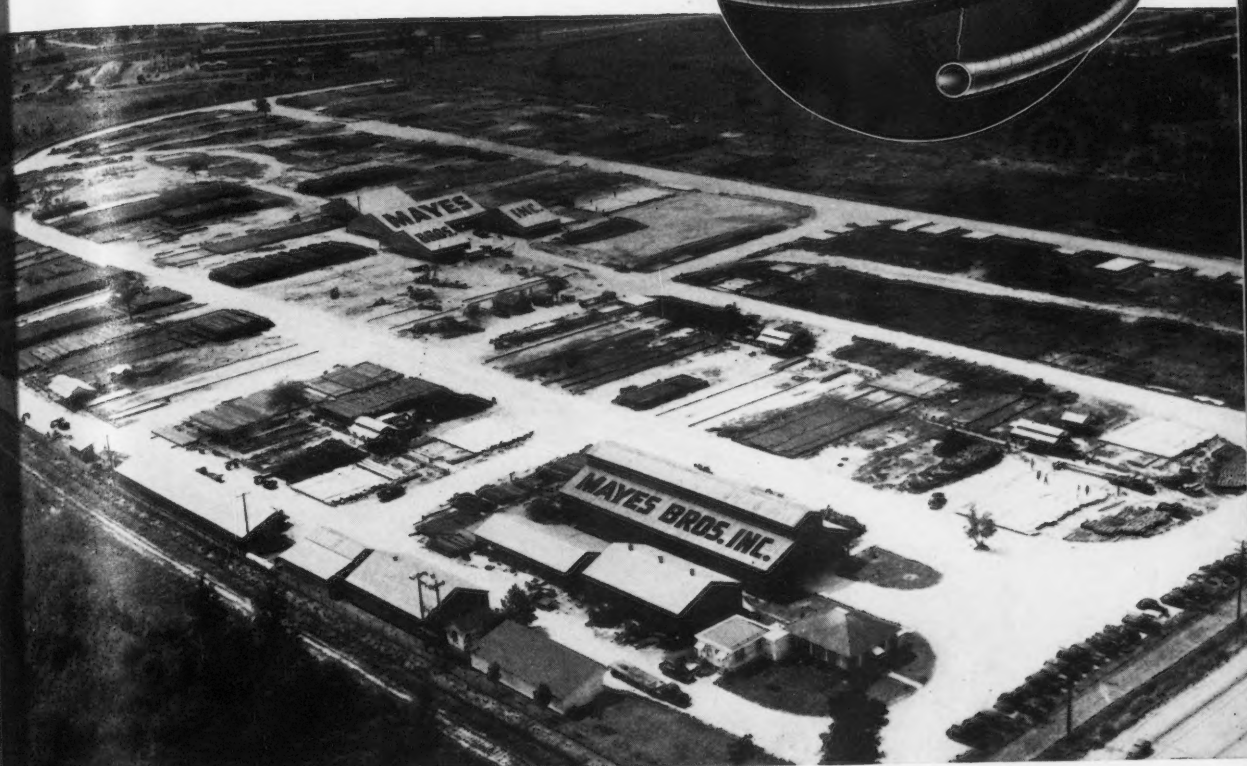
The Use of Oxygen in the Refining of Corrosion-Resisting Chromium-Nickel Steels. F. ILLIAN. *Stahl u. Eisen*, 71, 18-19 (1951) Jan. 4.

Account of experience at Deutsche Edelstahlwerke A.G. with 18-8 and constructional nickel-chromium steels. Workability and properties of the steels equalled those produced by conventional method. Life of the hearth was improved after initial difficulties. Using flask oxygen, charge of 100 percent chromium-nickel scrap showed carbon reduced to 0.05 percent. Nickel being recovered in full. Discussion on melting losses is included. Curtailment of time of oxygen treatment produced economics in electrodes and current.—INCO.

6.2.5, 3.4.6, 3.5.9

Corrosion [by] Hydrochloric Acid.—I-II. MARS. G. FONTANA. *Ind. and Eng.*

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Chem., 42, No. 8, 69A-70A; No. 9, 111A-112A (1950).

I.—A brief article pointing out that hydrochloric acid is a severe corrosive and that careful selection of materials of construction is required. Oxidation behavior of 18-8S stainless steel at 1800 degrees F. in different oxidizing atmospheres obtained as a result of an ONR research program is charted and discussed. II.—The metals and alloys generally used and suitable for handling the acid are discussed.

6.2.5, 3.8.3

Stainless Steels. H. H. UHLIG. *MIT Research Reviews* (ONR), 1951, 1-3, Feb.

The merits of stainless steels are outlined. Actually, there is more than just one stainless steel. There are several alloys, each made for a particular purpose, to which the name stainless steel is applied. All are composed mainly of iron, but contain at least 12 percent chromium and sometimes other metals. A steel must contain a minimum of 12 percent chromium in order to be stainless. Although the reasons for this are not exactly clear, the latest discoveries on the subject show some promise. It has been found, for example, that the amount of oxygen taken up by a clean surface of austenitic steel is very small—corresponding at most to a few molecular layers of metal oxide. This tends to eliminate the theory that chromium-oxide ions form the protecting surface. Rather, it is believed now, that the oxygen makes the alloy resist corrosion not by isolating the metal from its environment, but by lessening its tendency to react.—TDD.

6.2.5, 3.8.3, 2.3.5

Passivating Characteristics of the Stainless Steels. W. G. RENSLOW and J. A. FERREE. (Allegheny Ludlum Steel Corp., Brackenridge, Pa.) Paper, 7th Ann. Conf. Nat'l Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 10, 353-360 (1951) Oct.

While it has long been accepted that stainless steels have the inherent ability to passivate in air or under other oxidizing conditions, investigation indicates that the rate of film growth and the "degree of passivity" attained vary considerably under different conditions. Solution potential measurements offer a convenient means of following the progress of the film formation. Data show the behavior of stainless steel specimens in various solutions and in air after a prior chemical activation. A 30 percent nitric acid solution rapidly produces a passive potential as compared to air. A comparison of several stainless steel types in regard to their passivating characteristics is given and the effect of surface finish is also considered. Results suggest that in some instances stainless steels probably owe their corrosion resistance to the formation of a protective film of corrosion product on the surface rather than to the passive film which, according to the usual concept, is caused by an oxidizing environment.

6.2.5, 5.8.4, 3.2.2

Sodium Hydroxide As Inhibitor of Pitting in 18-8 Stainless Steel. J. W. MATTHEWS (Corrosion Laboratory Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.), H. H. UHLIG (Creole Petroleum Corp., Refinery Dept., Caripito, Venezuela), Pa-

per, 7th Ann. Conf. Nat'l Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 12, 419-422 (1951) Dec.

Stainless steels are exceptionally corrosion resistant to many corrosive environments. As a group, however, they possess the weakness of corroding by pitting in aerated solutions of chloride ions. This tendency can be overcome by addition of alkali.

Specimens of 18-8 were subject to an accelerated test at 90 degrees C. in 4 percent NaCl to which increasing amounts of NaOH were added. Without NaOH, an average of 14 pits formed within 24 hours on specimens measuring $5 \times 1 \times \frac{1}{8}$ inch, and corresponding average weight loss was 4.4 mdd. No pitting occurred if the solution contained more than 0.8 percent NaOH. The average weight loss in this concentration of alkali was 1 mdd.

In similar tests conducted at room temperature for 14 months, no pitting occurred in 4 percent NaCl containing at least 0.4 percent NaOH and weight loss was inappreciable. In these tests, it appeared that a more dilute alkali would also have been effective, although such tests have not yet been carried out. The mechanism of inhibition is discussed.

6.3 Non-Ferrous Metals and Alloys—Heavy

6.3.6

Reports on Miscellaneous Metallurgical Investigations. Failures and Defects of Brass Articles. *J. Birmingham Met. Soc.*, 30, No. 3, 92-116 (1950).

The results of four investigations of service failures are described: 1) The failure of brass nuts from the filling heads of an aerated-water machine. It is shown that the nuts were not defective, but were made from unsuitable material ($\alpha + \beta$ brass) which suffered severely, under the conditions of service, from dezincification and intergranular oxidation. 2) Investigation into the premature failure of (steel) welt needles. 3) Cracking of lipstick holder caps. The cracking is shown to be due to the hard condition of the pressings and the severe surface attack during bright dipping before lacquering. It is recommended that the pressings be bright annealed before lacquering; reduction in the severity of the attack during bright dipping is considered essential. 4) Surface imperfections on brass trays. It is shown that the defects are caused by dezincification present on the strip as supplied; the dezincification is intensified by the use of a used nitric acid pickle bath.—MA.

6.3.6

Corrosion Resistance of Copper and Copper Alloys. *Chem. Eng.*, 58, No. 1, 108-112 (1951) Jan.

Comprehensive data compiled by Am. Brass Co. on the resistance to common corrosives including acids, alkalis, ammonia, salt solutions, gases, organic compounds, fresh water, sea water, food products, petroleum refineries and steam. A chart gives relative corrosion resistance rating for various alloy under the general headings, copper, low-zinc, brass, high zinc brass, special brass, phosphorus-bronze, aluminum-bronze, copper-silicon alloys, copper-nickel and nickel silver to many corrosives. Composition table lists nominal compositions for copper, brasses, leaded brasses, spe-

cial brasses, copper-silicon alloys, copper-nickel, nickel silvers, leaded nickel silvers and special alloys. Some typical industrial uses of copper alloys are also tabulated.—INCO.



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6.3.6, 3.2.3, 3.4.6

Internal Oxidation of Dilute Copper Alloys. G. C. SMITH AND D. W. DEWHIRST. Australian Inst. Metals, Melbourne Branch, Phys. Met. Div. Preprint, 1950, 4 pp.

Contribution to a Symposium on Surface Treatment of Metals. II.—The Physical Bases of Impregnation Processes. When a dilute solution of some base metal in a more noble metal is heated in an oxidizing atmosphere, oxygen may diffuse into the alloy, producing a rim containing oxide of the base metal dispersed in a matrix of the noble metal. Oxidation at the surface of dilute copper alloys at elevated temperatures in air consists of: 1) surface oxidation with the formation of a scale of cuprous oxide, and 2) internal oxidation caused by advance penetration of oxygen into the dilute alloy. Results are given of metallographic studies of these alloys, relating hardness to size of the oxide particles. 18 references.—MA.

6.3.6, 3.5.8

Cracked Brass Pins. H. H. SYMONDS. *Metal Ind.*, 78, No. 2, 27-28 (1951) Jan. 12.

Results of an investigation into the stress corrosion of brass pins in storage. It was found that cracks were due to stress-corrosion and they existed on the tension or convex side. Extension cracking was present and transverse score marks existed. It was recommended that better surface protection should be given by the use of an increased plate thickness and by the use of a clear lacquer film over the tin coating.—INCO.

6.3.6

Copper and Copper Alloys—Technical Progress in 1950. E. Voce. *Copper Dev. Assoc. Metallurgia*, 42, No. 254, 382-390 (1950) Dec.

Continuous progress is being made in the metallurgy of copper and its alloys. This review of developments during the past year refers to the principal items of interest concerning such subjects as extraction, fabrication, finishing and properties. One important development in the extraction of copper is the revised form of the Orford process for the separation of copper from nickel as established by the International Nickel Co. New developments in rolling, production of tube and wire, deep drawings and hot working are reviewed. It has been found that the chief types of corrosion of copper alloys in marine service are impingement, pitting and deposit attack. Copper-nickel (30 nickel, 0.5-1.5 manganese, 0.4-1 iron) shows good corrosion resistance to pitting and deposit attack and is less effected by decaying organic matter than other materials. Welding, powder metallurgy, analysis and testing of copper are also included. 105 references.—INCO.

6.3.6, 2.3.4, 4.2.2

The Effect of Diffusional Processes on the Rate of Corrosion of Copper and Its Alloys. R. C. L. BOSWORTH. *J. Proc. Roy. Soc. N. S. Wales*, 83, No. 1, 8-16 (1949).

The corrosion of copper, brass, phosphor bronze and mild steel in acetic acid, acetic anhydride and their mixtures was studied with the use of a guard ring and circular disc arrangement to reduce the physical flow of corrosion products to a single dimension. The corrosion rate was least when the surface faced upward, and convective transfer was presumably absent. Diffusivity of the depolarizer (analogous to thermometric

conductivity) is of the order 5×10^{-9} cm.² sec.⁻¹ for the metals and corrodants studied.

6.3.8, 2.3.4, 4.3.6

The Solubility of Lead in Zinc Sulfate Solutions. C. W. BARKER, J. POWELL AND R. S. YOUNG. *J. Soc. Chem. Ind.*, 69, No. 12, 362-363 (1950).

In a laboratory study of the solubility of lead in zinc sulfate solutions over the range of variables normally encountered in electrolytic zinc refineries (zinc concentration 75-125 grams per liter, acid concentration 0.1-75 grams per liter, temp. 20°-30° C.), the lead solubility varied from 4.3 to 6.8 milligrams per liter decreasing with increase in acid concentration and increasing with increase in temperature. The concentration of zinc had practically no effect on lead solubility, little difference and no significant trend with regard to the latter being noted between the two extremes of zinc concentration.—MA.

6.3.8, 6.6.5

Accelerative Corrosion Reactions of Lead in Concrete. M. DODERO. *Metaux et Corrosion*, 24, 50-56 (1949).

Lead is attacked by calcium hydroxide present in concrete. Increased corrosion may be due to electrolytic effects. It is therefore necessary to avoid contact between lead and concrete, or protect the lead by suitable coatings.—RPI.

6.3.10

1) **Engineering Properties of Inconel.** 2) **Engineering Properties of "K" Monel and "KR" Monel.** International Nickel Co. Development and Research Div., Tech. Bull. Nos. T-7 and T-9 (Revised March, 1950, and Dec., 1949). 23 pp. each.

Mechanical properties of all forms of material, physical properties, hardness conversion chart, elevated and low temperature properties, heat treatment, corrosion resistance, working behavior, joining and finishing, forms available, uses, U. S. specifications.—BNF.

6.3.10, 5.9.2

Monel, Nickel and Inconel: Hot-Working, Annealing and Pickling. Henry Wiggin & Co., Ltd. Brochure, 1950, 51 pp. Available from the Company, Wiggin Street, Birmingham, 16.

Recommended procedures and much practical information. Deals with heating methods, temperature ranges for forging and bending, heating times, atmospheres, forging practice, die materials, properties of forgings; stress-equalizing and bright annealing, cleaning and degreasing, removal of tarnish, reduced oxide, oxide film and scale, machining discoloration, "coppering," embedded iron, etc.; paste pickles.—BNF.

6.3.10

The Engineering Properties of Monel, Nickel and Inconel. Henry Wiggin & Co., Ltd. Pamphlet, 1950, 20 pp. Obtainable from the Company, Wiggin St., Birmingham, 16.

Tables of properties: compositions; physical properties; tensile, shear, fatigue, compression and impact properties at room temperature, high-temperature creep and fatigue, low-temperature tensile and impact properties.—BNF.

6.3.15, 1.3

Titanium Rapidly Growing as Useful Engineering Material. W. T. TIFFIN AND

P. C. HOFFMAN. *Materials and Methods*, 33, No. 2, 57-59 (1951) Feb.

One of the most significant present-day developments in the field of metallic materials is the emergence of titanium and titanium alloys as useful engineering materials. Titanium is about two-thirds as heavy as steel, weighs 283.5 lb. cu. ft., and is a little less than twice as heavy as aluminum. Corrosion resistance is excellent, tensile strength is high and the melting point is 3137° F.—higher than most of the commercially available metals of today. This article reviews some of the information available on the metal: methods of production, mechanical properties and corrosion resistance. Tables showing comparative properties of titanium, 75ST aluminum and Type 304 stainless steel, resistance of titanium to chemical corrosion, and physical properties of hot-forged titanium bars at elevated temperatures are presented and the present and future applications of titanium and titanium alloys are discussed.—TDD.

6.3.20

The Corrosion of Zirconium; First Quarterly Report. HAROLD J. READ. Pennsylvania State College. Dec. 31, 1950. 7p. (NYO-835).

The activities of the Senior Investigator with respect to the acquisition of background information on the corrosion of zirconium are reported. Plans for the initial experimental work on the project are outlined. They involve a study of the formation of corrosion products on thin films of zirconium. This approach will permit the use of transmission methods for the study of the corrosion products by electron diffraction and electron microscopy.—NSA.

6.4 Non-Ferrous Metals and Alloys—Light**6.4.2, 5.9.4**

New Finish for Aluminum. *Metal Finishing*, 49, No. 1, 78 (1951) Jan.

Chemclean Products Corp., New York, has developed a new material for finishing aluminum, either as a base for paint or to protect the bare metal from corrosion, with the trade name of Protecto-Cote. It is provided already mixed and needs only to be dissolved in water, 6 oz. per gallon. Articles are immersed in the solution at 185° F (85° C) for about 5 minutes; no electric current is required. A high degree of adhesion is provided as a base for paint and the corrosion resistance is good.—ALL.

6.4.2, 4.6.11, 2.2.7

Report on the Resistance to Corrosion of Cast and Wrought Aluminum Alloys in Sea Water; Aluminum Company of America, ... Washington, D. C., Exhibitor. J. L. BASIL. U. S. Naval Engineering Experiment Station, Annapolis, Md. Report C-3371-C, Feb., 1950.

Samples of nine wrought and six cast aluminum alloys were exposed from December to June in sea water at 50-70° F flowing at the rate of 3 fps. The corrosion resistance of the wrought alloy 52S-1/2H (2.5 magnesium-0.25 chromium) was excellent, and that of the wrought alloy 62S-T5 (0.4 silicon-0.4 magnesium) was fair. The other alloys had poor resistance and would be se-

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verely damaged by prolonged exposure to flowing sea water.

The wrought alloys 75S-T6 (1.6 copper-2.5 magnesium-5.6 zinc-0.3 chromium), 61S-T6 (0.25 copper-0.6 silicon-1.0 magnesium-0.25 chromium), 4S-1/2H (1.0 manganese-1.2 manganese), and 3S-1/2H (1.2 manganese) pitted to a depth readily measurable by depth gage or pointed micrometer. An Alclad sample was penetrated to the 3S core, indicating that the coating alloy (72S) had comparatively low corrosion resistance. Two samples of 72S- (1.0 zinc) showed no pitting on the surface but corrosion started at the edges and penetrated from one edge to the other. Evidence of intergranular corrosion was observed in the wrought alloys 61S-T6, 75S-T6, and 24S-T (4.5 copper-1.5 magnesium-0.6 manganese).

Of the cast alloys, 220-T4 (10.0 magnesium) and 356-T6 (7.0 silicon-0.3 magnesium) and 214 (3.8 magnesium) were the most resistant to corrosion. Alloys B-214 (1.8 silicon-3.8 magnesium) were most susceptible to pitting attack. Alloys B-214, 220-T4, 356-T6, 43 (5.0 silicon), and 195-T5 (4.5 copper-0.8 silicon) showed evidence of intergranular corrosion.

Test specimens were bolted at each end to a rectangular micarta rack. The racks were laid in a trough so that they were 2 inches above the bottom and 3 inches below the water surface. The direction of flow was normal to the longitudinal edges. The test site was Kure Beach, N.D.—PDA.

6.4.2, 4.2.6, 4.2.5, 4.2.4

Weathering of Some Aluminum Alloys. *Light Metals*, 13, No. 147, 215-221 (1950).

Four aluminum alloys, 2S, 3S, 50S and 51S, known to have high resistance to atmospheric corrosion, were observed after long exposure to rural, industrial and marine atmospheres in the United Kingdom and other countries having similar climates. The surface appearance of the aluminum varied with exposure and with regularity of cleaning. Aluminum in rural zones remained bright without cleaning for long periods, then gradually darkened but maintained a smooth surface. In industrial zones aluminum darkened more quickly than in rural zones; after many years of exposure the rough adherent film formed a surface that resembled weather stone. In marine exposure aluminum acquired a light and dark mottled appearance. The weathering effect was retarded in all these exposures by the washing action of rain; thus aluminum in sheltered positions was affected more rapidly by weathering than unsheltered aluminum.

The original appearance of aluminum was retained for many years by cleaning with soap and water or mild household powder at intervals dictated by the severity of exposure; on the average, cleaning two or three times a year sufficed. Anodized aluminum finishes for outdoor work should in general be confined to areas where regular cleaning is possible.

Surface pitting is practically the only type of corrosion affecting aluminum. The degree of pitting during the first 1-2 years of exposure was dependent on location and atmosphere. Roughly, surface pitting can be expected to amount to 0.05 mm in rural atmospheres, 0.10 mm in industrial areas, and 0.15 mm in marine exposure. The rate of surface pit-

ting decreased rapidly after 1-2 years to reach a steady rate of approximately 0.003 mm per year under most conditions for all exposures in the United Kingdom as well as in the United States.

Where corrosion was uniform, tensile strength was decreased as cross-sectional area decreased; elongation was slightly reduced. Where corrosion was characterized by pitting, stress concentrations were produced that resulted in reduced elongation, and to a lesser extent, decreased tensile strength.

Normal protection precautions in design and erection technique such as the insulation of joints between aluminum and dissimilar metals, back-painting of aluminum in humid atmospheres and precautions against condensation are essential to derive full advantage of the durable qualities of aluminum.

The 2S alloy was commercially pure 99.25 percent aluminum; the 3S contained 1.25 percent manganese; the 50S contained 0.625 percent magnesium and 0.5 percent silicon; and the 51S contained 0.625 percent magnesium and 1 percent silicon.—PDA.

6.4.2

Industry Widens Uses of Aluminum Tubing. *J. ANTHONY. Iron Age*, 165, No. 10, 103 (1950) March 9.

The heat exchanger market has consumed 250,000 pounds of aluminum in the form of tubing during the post-war years, as compared with a prewar total of 10,000 pounds total consumption of the market. Typical installations include vapor recovery condensers, lube oil coolers, hydrogen sulfide gas coolers, furfural condensers, MEA solution coolers and exchangers and MEK service. The sub-zero physical and mechanical properties of aluminum are very good; strength and ductility improve at low temperatures. Aluminum alloy 61S has a tensile strength of 45,000 psi and an elongation of 17 percent at room temperature; at -320 degrees F. (-196 degrees C.) the tensile strength is 60,000 psi and ductility 22 percent. Certain chemical and petroleum industry installations including plants for the syntheses of gasoline from natural gas and petrochemical plants use aluminum heat exchangers. Production of Alclad aluminum in the form of tubing which is protected from electrolytic corrosion and is cold-drawn from extruded blooms has expanded the market. A new type of hollow extruded tubing with longitudinal fins on the external and internal surfaces has been developed and facilitates heat transfer by the greater inner and outer exposed surfaces. Several manufacturers will provide a complete line of standard and large size fittings such as flanges, tees, caps, stub ends, reducers, manways, ell's, etc. Electronic tube expanding equipment has been developed which will produce uniformly strong and tight joints between tubing and tube sheets quickly and economically. The equipment is set to a predetermined stress, at which point it shuts off automatically. Large exchanger installations made of heavy 1½-inch thick aluminum plate can be welded automatically in two passes using an argon gas shielded arc.—ALL.

6.4.2, 4.3.6, 2.3.5

Surface Reaction Between Aluminum and HgCl₂. *G. BOLOGNESI. Alluminio*, 18, No. 5, 493-497 (1949).

Bolognesi, by means of electrochem-

ical measurements, has studied the effect of mercuric chloride on aluminum 99.5 percent, 99.9 percent, and 99.99 percent pure. The concentration range of the mercuric chloride was N/500 to N/100,000 and two different types of surface polishing were considered. 16 references.—MA.

6.4.2, 8.9.1, 5.3.4

Corrosion Aspects of Fusion Welded Aircraft High-Strength Aluminum Alloys. *LOREN W. SMITH. Paper, 5th Ann. Conf. Nat'l Assoc. Corrosion Engrs., Cincinnati, Ohio, April 11-14, 1949. Corrosion*, 7, No. 12, 423-437 (1951) Dec.

While the mechanical joint strength efficiencies of fusion welded high strength aluminum alloys have been considerably improved by new welding processes, the uncertainty of the lowered corrosion resistance of the welded alloys due to the deleterious effect of the heat involved has been a major obstacle to the extended use of welded aluminum alloys of the 24S and 75S types for aircraft structures.

This article discusses the metallurgical structures resulting from the fusion welding of aluminum alloys and correlates these structures with the resulting corrosion data. The results of several investigations on the corrosion resistance of fusion welded 24S, 61S and 75S aluminum alloys are reported. Tensile strength comparisons of bare and clad welded alloys exposed to corrosive mediums in the as-welded, aged and reheat treated conditions are made.

The protective value of cladding and the restoration of the original parent metal structure by reheat treatment are demonstrated by the accumulated corrosion data for the high strength wrought aluminum alloys used in aircraft construction.

Conclusions from these laboratory and outdoor exposure corrosion studies are made and recommendations are offered for the fusion welding of the high strength aluminum alloys with the optimum corrosion resistance.

6.4.2, 3.4.8, 5.9.4

Defects of Anodic Oxidation Due to the Presence of Chlorides. (Défauts d'oxydation anodique dus à la présence de chlorures). *J. HERENGUEL AND R. SEGOND. Rev. aluminium (France)*, 26, No. 152, 52-54 (1949) Feb.

Anodic oxidation causes the formation of an anhydrous oxide film on aluminum which will check electrolysis of the character of the pores was not formed by attack of the electrolyte. A very violent attack, due particularly to the presence of chlorides, dissolves this film completely and causes the aluminum to deteriorate. These chlorides can be found in the electrolyte, producing a generalized attack; or they are assimilated in the aluminum as a result of either a poor refinement of metal conduit or welds insufficiently freed from their flux by washing, leading to local attacks. The electrolytic bath must have a chlorine strength of less than 0.4 percent. It is concluded that chlorides create a great disturbance in the mechanism of anodic oxidation since the very active chlorine ions enter deeply into the interior of the oxide film during oxidation; they provoke severe corrosion. With the metal containing chloride inclusions, involving very severe local corrosion, the chlorine ions remain in elevated concen-

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trations, and produce intense anodic dissolution. These inclusions can have various origins; foundry flux for rolled pieces, welding flux for welding assemblies, and bad fluxes after soldering. The use of welding flux containing only fluorides which do not involve this type are recommended. The electrolytic bath itself can contain chlorine ions. When their strength is weak enough, the oxidation film is attacked generally with a lessening of stiffness. If the strength exceeds a limited value, local corrosion appears as in the case of chloride inclusions. The strength of chlorine in the electrolytic baths must therefore be verified regularly.

6.4.4, 3.4.1, 3.7.2, 5.9.2

Methods for the Protection of Magnesium Alloys. W. F. HIGGINS. Ng. Elektron Ltd. *Electroplating*, 3, No. 8, 287-291 (1950) April.

Corrosion protection of magnesium and its alloys is discussed. The strong mineral acids in aqueous solution attack magnesium rapidly, while the long-chain fatty acids are inert. The continuance of attack is dependent on the solubility of the product. Chromic acid brings on a passive condition of the surface which resists further attack, while hydrofluoric acid forms a protective film which rapidly brings reaction to an end. Magnesium is inert to alkalis, due to the formation of protective films and thus is directly opposite from aluminum. Chloride ions are able to penetrate protective films and lead to corrosion. Protection is afforded by alloying with less susceptible metals as manganese and zirconium, chemical or electrochemical treatment and erection of physical barriers as paint, rubber sprays, etc. Chemical treatment by means of chromate, fluoride, phosphate or carbonate dips is described. The disadvantages and advantages of each of these protective means is discussed. To give galvanic protection, all steel or brass parts should be cadmium or zinc plated before joining to magnesium and "wet assembled" with chromate solutions.—INCO.

6.5 Metals Multiple or Combined

6.5, 3.5.8, 3.4.6

Studies on Surface Chemistry; Progress Report on Research Project. GEORGE RICHARD HILL, MELVIN A. COOK, W. MARTIN FASSELL, JR., AND RANSOM B. PARLIN. University of Utah. Nov. 27, 1950. 30 p. (AECU-1117).

Information on work in progress on the following problems is presented in some detail: the primary corrosion process in cobalt, nickel and iron and their alloys; oxidation of metals at high temperatures and high pressures; and theoretical investigation of the nature of contact catalytic surfaces and processes in the catalytic hydrogenation of propylene.—BLR.

6.6 Non-Metallic Materials

6.6.8

Influence of Additions of Surface-Active Substances on Basic Properties of Cement Solutions and Concretes. (In Russian.) A. V. SATALKIN AND M. B.

KUBLANOVA. *Zhurnal Prikladnoi Khimii* (Journal of Applied Chemistry), 23, 1023-1031 (1950) Oct.

Influence of additions of caustic sulfites and their derivatives and of sodium abietate on plasticity, strength, deformability, shrinkage in air, frost resistance, water permeability and chemical stability were investigated. Method of investigation is described. Data are charted and tabulated. 11 references.—BLR.

6.6.8

Synthetics as Corrosion Protection. W. HAWERKAMP. *Kunststoffe*, 40, 17-22 (1950); *Chem. Abs.*, 44, 4405 (1950).

Chemical, mechanical and thermal properties are compiled for materials made of polyvinyl chloride (Vinidur) and polyisobutylene (Oppanol). Numerous examples of apparatus built of them are described and a table is added giving gases and liquids against which the material is resistant.—MA.

6.6.8, 2.3.4, 5.4.5

The Chemical Resistance of Phenolic Resins. RAYMOND B. SEYMOUR. Presented before the Division of Paint, Varnish and Plastics Chemistry at the 118th National Meeting of the American Chemical Society, Chicago, Ill., September, 1950. *Corrosion*, 7, No. 5, 151-154 (1951) May.

Because of their outstanding resistance to solvents, salts and non-oxidizing mineral acids, coatings, chemical equipment and cements derived from phenolic resins are used widely in the chemical, steel, paper, petroleum, food, textile and plating industries. Practical experience and laboratory test data show phenolic resins to be unsuitable for use in presence of nitric acid, chromic acid or strong alkalis but to be resistant to most other common industrial chemicals at temperatures up to 375 degrees F.

A test procedure has been developed in which the weight change of phenol-formaldehyde coupons is determined for various time intervals and specific chemical resistance data are tabulated. Installations are cited in which brick joined with phenolic resin cement have been in continuous hot acid service for over ten years.

6.6.10, 2.3.3

Recent Developments in Fabric Preservation. R. E. VICKLUND, M. MANOWITZ. U. S. Engineer Center, Engineer & Research Development Lab., Rept. No. 1098, 27 pp. 1949.

Comparison of the fungicidal effectiveness of several copper compounds with various other textile preservatives is described. Copper 8-quinolinate gave the best results.—RPI.

6.7 Duplex Materials

6.7.2, 3.4.6, 3.5.9

Mechanism of Cermet Oxidation at High Temperatures. W. B. CRANDALL, H. S. LEVINE, G. E. LOREY, AND V. D. FRECHETTE. Alfred University. Oct. 1, 1950. 12p. (NP-1763).

Among the many factors that determine the usefulness of a metal-ceramic mixture is its resistance to oxidation in air at high temperatures. The mechanism of oxidation of cermets is not well known. It was the purpose of this investigation to evaluate each of the variables which affects the oxidation rate of

cermets and to establish a general mechanism by which oxidation proceeds. The progress of oxidation was followed by observing 1) the rate of penetration of an oxide layer into the cermet body, and 2) the weight gain as a function of time during exposure to air at temperatures from 600 to 1000 degrees C. Dispersed binary mixtures of cobalt and aluminum oxide were taken as a model system and extensively studied by these two types of experiments with metal concentration, porosity and temperature as variables. These studies were supplemented with weight-gain experiments on binary mixtures of the metals iron, cobalt, and nickel with the oxides aluminum oxide, beryllium oxide, chromic oxide, zirconium oxide, and magnesium oxide. It is concluded that the progress of oxidation in a cermet body is controlled by the rate of change of oxygen concentration in the pore structure of the cermet body. The porosity, metal concentration, temperature, oxidation state and oxidation rate of the metal and diffusion rate of oxygen are variables which influence the oxygen concentration change.—NSA.

6.7.2, 3.5.6, 3.5.9

Cermet Oxidation Studies. W. B. CRANDALL. *Alfred Univ. Research Review* (ONR), 1950, 1-4, Oct.

The results of studies made on the oxidation resistance of cermets are presented. Cermets, which are composed of metal-ceramic combinations, were developed for application in aircraft and atomic power plants where they must withstand high temperatures and stresses. Two methods were used in the studies; measurement of the percent of weight gain as a function of time; and measurement of the thickness of the oxidized layer as a function of time. The studies showed that there is initially a rapid gain in specimen weight which tapers off. The period of rapid gain corresponds to the time during which the oxide layer is penetrating the specimen. The actual rate of oxidation or oxide penetration appears to be affected by the concentration of the metal; the greater the concentration, the slower the oxidation. Other factors in the rate of oxidation are: porosity of the cermet; shape; temperature; oxidation rate of the metal component; particle size; and partial pressure of oxygen.

6.7.2, 3.5.9

Fundamental Properties of Metal-Ceramic Mixtures at High Temperatures. W. B. CRANDALL AND W. G. LAWRENCE. Alfred University. Nov. 30, 1950. 10p. (NP-1823; Periodic Status Report No. 23).

A hot-pressing device was constructed and a technique was developed whereby specimens with low porosities could be prepared rapidly. Two- and three-component systems were among those prepared by this method. A disk-type specimen was incorporated in the oxidation weight-gain studies for the purpose of maintaining constant oxidation areas for longer periods of time. Oxide-layer specimens of low porosity were prepared. Quantitative x-ray analyses were made on these specimens and correlated with water absorption data to obtain the relationship between open and closed pores. A method for characterizing thermal-shock resistance was developed.

based on the assumption that failure occurs when any of the thermal stresses becomes greater than the strength of the test body. A hypothesis was developed that includes oxidation, diffusion and heat-conduction phenomena as variations of the same problem which is based upon the effect of two opposing diffusion processes.—NSA.

6.7.2, 4.7

Fundamental Concepts in Sintering and Properties of Cermets of the Oxide Metal Type. T. S. SHEVLIN AND G. A. BOLE. Ohio State University. Paper before Electrochem. Soc., Electrothermic Div., Cleveland, April 19, 1950. *Engineering Experiment Station News*, 22, No. 4, 22- (1950) Oct.

Discussion of wetting, bonding and sintering properties of cermets. Experiments in which surface oxidation of molten nickel or cobalt in contact with magnesia causes lowering of the contact angle, reinforce the proposed theory of the wetting mechanism. The procedure is given. 7 references.—INCO.

6.7.2

Ceramics—Silicon Ceramics—Metal Ceramics; Production of Metallic Articles by the Ceramic Method—Metallic Ceramic Materials. MAX HAUSER. Battelle Translation, 2 pages. From *Sprechsaal für Keramik*; Glas; Email, 83, 42-47 (1950) Feb. 5.—BLR.

7. EQUIPMENT

7.1 Engines, Bearings, and Turbines

7.1

Five Diesel Valve Troubles: What Causes Them; What Relieves Them. SAE Journal, 58, 58-63 (1950) Sept.

Excerpts from "Valve Problems in Diesel Engines," by Vincent Ayres. Discusses breakage, seat wear, valve-face guttering, stem and guide wear and sticking. Fundamental causes, including design, materials of construction, fuels and lubricants are considered. Gives recommendations.—BLR.

7.1, 4.4.6

Corrosion by Leaded Petrol. *Mech. World*, 128, No. 332, 216 (1950) Sept. 1.

Tests on 18 alloys showed that under cyclic temperature conditions the products of combustion of gasoline containing TEL cause corrosion by behaving as though they increased the effective oxygen concentration. High oxygen content plus lead oxide produces a very corrosive condition. In long tests at constant temperatures, lead oxide with 3 percent oxygen was less effective than air alone. It is suggested that corrosion caused by combustion products of leaded fuel may be due to lead oxide alone and that lead bromide may assist the production of a liquid deposit containing lead oxide.

7.1, 6.5

Gas Turbine Alloys, 10 Years Later. H. SCOTT, Westinghouse Res. Lab. *Metal Progress*, 58, No. 4, 503-511 (1950) Oct.

The past and future of high-strength alloys suited for service above maximum steam temperatures is discussed. Representative high-strength alloys including Uniloy 19-9DL, EME, Inconel X, several Haynes Stellite alloys, have been grouped

on the basis of available forms, namely, as wrought products and as complex shapes obtained by precision investment casting for the purpose of this discussion. The experience gained with these alloys is reviewed and the probable trends in the future development of high-strength, high-temperature alloys are outlined. It is concluded that present high-temperature alloys are limited by deficient ductility; future turbines operating at 1700° F will require alloys based on chromium, molybdenum or titanium—or on pure molybdenum with an oxidation-resistant coat.—TDD.

7.1, 4.3.3

Gas Turbines for Industrial Purposes. A. T. BOWDEN. Paper before Section G, British Association, Sept. 1, 1950. *Engineering*, 170, 214-216 (1950) Sept. 8.

Advantages and limitations of gas turbines vis-a-vis Diesel engines and steam turbines, problems peculiar to large industrial gas turbines, as compared with smaller types, fields of application in industry for gas turbines of various sizes. Problems of attack by vanadium pentoxide are discussed.—INCO.

7.1

Critical Review of Gas Turbine Progress 1950. *Engineer*, 191, 50-52 (1951) Jan. 12.

Account of developments in land turbines in U. S. A., S. America, France, Switzerland, Great Britain, with notes on progress of installations under construction. Section is devoted to new plants coming into service. Gas turbines in locomotives are discussed. In section dealing with vanadium attack, Amgwerd's work at Zurich is reviewed, with notes on confirmation of general validity of findings. General rule is probably sound that alloys in which good creep properties are obtained by large additions of cobalt or molybdenum are particularly sensitive. 18-8 stainless iron is fairly resistant and Nimonic 80 only slightly attacked. Pure chromium is not attacked and hence some hopes are based on heavy chromium-plating of other materials so as to produce impervious protecting layer. Notes on methods for obviating vanadium attack and on nature and incidence of attack are given. Section on water in compression system and its effects is included.—INCO.

7.1

High Temperature Steels and Alloys for Gas Turbines—No. 1. *Engineer*, 191, No. 4963, 313-314 (1951) Mar. 9.

A symposium on high-temperature steels and alloys for gas turbines was held by the Iron and Steel Institute February 21-22, 1951, at the Institution of Civil Engineers in London. A general review is given of the papers presented at the symposium. In opening the meeting, Sir Andrew McCance said that the subject of the symposium was one of vital importance. Owing to the scarcity and increasing cost of fuel, engineering minds had been turning to the development of machines and engines that would give a higher thermal efficiency. For that purpose they were thinking of regions of temperature in which difficulties in connection with the materials were showing themselves only too clearly. The object of the symposium was to discuss such problems, many of which were highly complex and intricate.—TDD.

7.1

Experimental Running of Open- and Closed-Cycle Gas Turbines. J. B. BUCHER. *Trans. Inst. Engineers and Shipbuilders in Scotland*, 1950, 275-310; disc. 310-320.

Extremely detailed account of work carried out by John Brown and Company, on the two types of turbine, using gas oil and Britoleum. Blade materials tested were R.ex 337 A, G.18B, Staybrite F.C.B., cold-worked F.C.B., Nimonic 80, and Nimonic 80 A. Examination of deposits in turbine showed nickel oxide 13.7, chrome oxide 18.6, iron oxide 48.4, silica 2.4, sulfate 3.4, vanadium pentoxide 8.3 percent and traces of lime and magnesia. The rotor blades, except those made from materials having high nickel content; showed distinct signs of sealing, and all blades, with exception of those having high nickel content, had been attacked by the vanadium pentoxide. Conclusion is drawn that considerable difficulties will be experienced in running open-cycle gas turbines on anything other than distillates, unless a method of cleaning blading without shut-down can be developed. In the discussion T. F. Eden deals in some detail with vanadium pentoxide attack and indicates that in corrosion, troubles will be experienced only if the metal temperature is above the melting point of the ash (given as 690 degrees C.). In reply, the author (p. 319) refers to further running of the closed-cycle unit on Britoleum.—INCO.

7.2 Valves, Pipes and Meters

7.2, 8.4.3

Unusual Control Valve Practices in a Refinery. C. W. BATES AND J. R. MARTIN. Humble Oil & Ref., Co. *Petroleum Refiner*, 30, No. 1, 111-118 (1951) Jan.

Control valve problems and method used to solve them. Sulfur deposits in control valves, split ranging of control valves, special control valve body from Hastelloy tee, control valves for pilot units, butterfly-type control valves, positive shut off valves, control valves bypass manifold, addition of automatic control, reverse flow through a valve, and hydraulically operated control valves are discussed. For controlling the flow of black acid, angle valve bodies were used. The plugs were made of Hastelloy B. A body design was adapted using Hastelloy tees as a base. These valves were packed with shredded Teflon but this has been changed to braided Teflon packing.—INCO.

7.2, 8.9.3

Pipe Thickness as Related to Pipe Life. M. E. PARKER. *Oil Gas J.*, 49, No. 48, 106 (1951) Apr. 5.

A consideration of the effect of pipe thickness on pipe life in three cases involving nonaggressive, average and corrosive soil leads to the conclusion that any permanent line of any length will be most economically maintained in the long run if the pipe used is of a thickness dictated entirely by operating conditions with no allowance whatever for corrosion. Such lines should be coated and wrapped throughout. A layer of steel is a very ineffective as well as expensive coating for a pipe line.

7.2, 5.4.8

Modern Methods of Protection for Cast Iron and Steel Pipes and the Practice of These Methods in Holland. Gas-

u. Wasserfach, 91, 89-90 (1950). *Werkstoffe u. Korrosion*, 1, No. 11, 464 (1950).

The protection of iron water pipelines is carried out with compositions based on blown asphaltic bitumens. Details of the required physical properties of the bitumen and the thickness of the coatings for various degrees of protection are given.—RPI.

7.2, 6.4.2

Aluminum Pipe Lines. W. B. MOORE, Reynolds Metals Co. *Welding Engr.*, 35, 26-29 (1950) July.

Aluminum pipe lines are being used to transport oil, natural gas, and other fluids generally carried in steel lines. Comparative costs show a considerable saving for the aluminum installation, though its first material cost is higher. Advantages are: light weight of aluminum simplifies handling problems; reduced fluid friction; savings on overhead and aerial river crossings; corrosion resistance makes it unnecessary to wrap pipe; and aluminum scrap has high recovery value.—TDD.

7.3 Pumps, Compressors, Propellers, Impellers

7.3, 4.6.2, 2.3.7

Corrosion-Erosion of Boiler Feed Pumps and Regulating Valves at Marysville, Second Test Program. J. M. DECKER, H. A. WAGNER AND J. C. MARCH, Detroit Edison Co., Detroit, Am. Society of Mechanical Engineers, New York, Paper 48-A-118. *Trans. Am. Soc. Mech. Engrs.*, 72, 19-26 (1950) Jan.

Two carbon steels, six chromium-bearing steels and two bronzes were exposed for 500 hours to corrosion-erosion by high velocity, turbulent feedwater under conditions similar to those encountered in boiler feed pumps and regulating valves.

The rate of attack on carbon steel decreased with an increase in temperature of the feedwater from 250° to 385° F. On chromium-bearing steels, the attack was greatest at some point between these two temperatures. Since the chromium alloys were still much more resistant at all temperatures than carbon steel, they are considered satisfactory for service up to 400° F in boiler feed pumps and regulating valves in feedwater having similar characteristics. Chromium plating as a means of protecting existing carbon steel pump casings was not satisfactory.

A 1.25 chromium-0.5 molybdenum steel and a 0.79 chromium-0.66 nickel-0.25 molybdenum steel were not attacked to a significantly greater extent than the 5 and 12 chromium steels at the higher temperatures and therefore, because of greater weldability and lower cost, the low chromium alloys may be used advantageously under similar or less corrosive conditions.

Leaded bronze (70 copper-26 lead-4 tin) was not a good material at 250°-400° F under conditions conducive to corrosion-erosion. Navy M bronze (87.58 copper-5.90 tin-4.14 zinc-1.64 lead-0.49 nickel-antimony-iron-phosphorus-sulfur) was satisfactory up to about 320° F.

Neither the causes nor the most important factors involved in the corrosion-erosion attacks could be determined. Increasing the pH of the feedwater from about 7.6 to 8.4 at 250° F, however, approximately doubled the rate

at which cast carbon steel was attacked. This indicates the desirability for keeping the water at the lower pH in this particular feedwater and for exercising some caution in increasing feedwater pH values indiscriminately as a panacea for all corrosion-erosion troubles.—PDA.

7.3, 8.4.3

Keep Your Pumps on Stream. L. J. DAWSON, Ingersoll-Rand Co. *Petroleum Engr.*, 22, No. 12, C13+ (1950) Nov.

Article describes the mechanical details and maintenance of centrifugal refinery pumps. The proper selection of correct mechanical design to fit the application is important in keeping maintenance low. For neutral liquids, moderate temperatures and pressures, a cast iron casing, bronze impeller and impeller rings and cast iron rings are used. For highly alkaline liquids, iron parts are used; for moderately acid liquids, bronze is used. For higher temperatures and for volatile liquids, a steel pump is indicated while for sour and corrosive oils, popular steel alloys are 4-6 chromium, 0.5 molybdenum, 11-13 chromium, 18 chromium-8 nickel, or 18 chromium-8 nickel-3 molybdenum. For shaft sleeves, Nitralloy is available and has the advantage of retaining hardness at temperatures up to 1000° F. For corrosive conditions, a hardened stainless steel or a Stellite sleeve is required such as 18 chromium-5 nickel with sub-zero precipitation hardening to 425 Brinnell. Sufficient lubricant of the proper grade for the service and periodic changes to remove condensation and contamination are also important factors in maintenance.—INCO.

7.4 Heat Exchangers

7.4.2, 6.4.2, 8.2.2

Heat Exchangers at Fulham Power Station. *Light Metals* (England), 13 No. 152, 515-518 (1950) Sept.-Oct.

Prolonged service tests on aluminum, anodized aluminum and steel heater elements of the Ljungstrom heat exchanger at Fulham power station have revealed that aluminum and anodized aluminum components are more resistant to corrosion and give longer service. After a total steaming period of 12,500 hours in Boiler No. 8 the aluminum plates showed a weight loss of 11 percent but retained a surface entirely free from corrosive pitting. Mild steel elements showed a weight loss of 7½ percent after 1700 hours steaming and were unfit for further service after 12,000 hours. It is calculated that the aluminum plates would be eroded to half the original thickness after 65,000 hours steaming, or ten years of life. Results showed that anodizing was of no benefit. Boiler No. 10 was fitted with aluminum cold-end elements in 1947 and up to July 1, 1950 had steamed 12,332 hours with completely satisfactory results. A 10° F (5.5° C) reduction in temperature has been realized which represents an overall increase of 0.03 percent in boiler efficiency.—ALL.

7.4.2, 3.3.2, 1.3

Control of Condenser Fouling by Water Treatment. RALPH M. WESTCOTT, *Refrig. Eng., App. Data*, Sect. 46, 6 pp (1949) May.

A review.—RA.

7.4.2, 8.4.3, 6.2.2

Corrosion of Cast Iron Tubes in a Petrol Condenser. (In Italian.) R. SALE. *Calore*, 21, No. 5, 180-182 (1950) May.

An examination of corrosion occurred in a condenser installed in a petrol refinery. Suppositions on the corrosion mechanism are put forward upon a metallographic examination of cast iron and an examination of encrustation.—MI.

7.4.2, 8.9.5, 4.6.11

Materials for Use in Ships' Condensers and other Seawater-Carrying Systems. P. T. GILBERT AND R. MAY, *Trans. Inst. Marine Engrs.*, 62, No. 8, 291-294 (1950) Aug.

Indicates materials available for the various components of ships' condenser systems and other metallic parts in contact with sea-water, and the conditions in which these various materials can be used. Includes descriptions of the various types of corrosion liable to occur in these systems.—BNF.

7.4.2, 4.6.2

Corrosion of Preheater Tubes. (In German.) W. KATZ. *Metalloberfläche*, sec. A, 4, 161-168 (1950) Nov.

Causes of corrosion of tin-bronze and aluminum-bronze tubes carrying salt solutions and externally heated with superheated steam were investigated. Corrosion of tin-bronze tubes is explained by the formation of local galvanic currents, while the intergranular corrosion of aluminum-bronze tubes is caused by tensile stresses resulting from the high temperatures of the steam. Includes macrographs and micrographs.—RPI.

7.5 Containers

7.5.5, 6.2.5, 8.4.3

Stainless Steels for the Bottoms of Tanks Containing Sour Crude Oil. C. P. LARRABEE AND W. F. ROGERS, *Corrosion*, 7, No. 8, 276-278 (1951) Aug.

The results of tests made for periods of six months and one year under conditions similar to those existing on the bottoms of tanks containing sour crude oil indicate that the austenitic stainless steels have a satisfactory resistance to corrosion and thus are suitable as constructional materials for the bottoms of sour crude oil storage tanks.

7.5.1, 4.3.1, 4.4.1, 5.3.2, 5.4.5

Metal Containers M. T. LACRUE AND R. M. MARTINEZ, *Cons. sup. Invest. científ* (iii), 1, 15-29 (1943).

Parallel corrosion tests were carried out on untreated and lacquered iron and tinplate in aqueous solutions of hydrochloric acid, citric, tannic and oxalic acids, sodium carbonate, sodium chloride, olive oil containing oleic acid and alcohol, at room temperature and at 100°. The effect of dissolved air was investigated. Lacquered iron is more resistant than is tinplate to attack by cold acids, but is more rapidly attacked at 100°. Alcohol and olive oil containing oleic acid partly dissolve the lacquer used. Lacquered iron is more rapidly attacked than is tinplate by aqueous sodium carbonate and sodium chloride in the cold and is less resistant to corrosion at 100° than is tinplate for all the reagents tested. Dissolved air markedly increases the rate of corrosion.—RPI.

7.5.2, 8.3.5

Varnishes for Food Containers. *Ind. della Vernice*, 4, No. 40, 156 (1950).

Effects of acid products in food containers and the necessity for protection by varnishes are discussed. To reduce the blackening produced by shell-fish, etc., a small amount of zinc oxide is added to a typical gold size.—RPI.

7.6 Unit Process Equipment

7.6.4, 5.1, 3.5.2, 2.4.4

Sulfur, Dew Point and Boiler Availability. STEPHEN JUHOAG. *Combustion*, 20, 155-158 (1949) June. Translated and condensed from *Tennick Tidskrift* (Sweden) Jan. 22, 1949.

Sulfur content of fuel and flue gas is discussed in relation to deposits and corrosion of boiler and superheater surfaces. Problems of dew-point measurement are outlined, and a dew-point meter developed by the author is described. The economics of corrosion-resisting materials is considered and means of reducing corrosion difficulties are analyzed.—BLR.

7.6.4

Intercrystalline and Other Types of Corrosion of Steam Boilers. R. E. COUGHLIN ET AL. *Bull. Am. Ry. Eng. Assoc.*, 490, No. 223 (1950) Nov.

Recommendation was made that in conditioning water for steam boilers on railroads, the sulfate-alkali ratio outlined in the ASME Boiler Code which has been found of questionable value and increases operating difficulties, be disregarded and that lignin or nitrate

treatment be used where embrittlement detector specimens indicate water of questionable character.—A.W.N.A.

7.6.4

Special Characteristics of Processes Inside High-Pressure Steam Boilers During Operation. (In Russian.) M. A. STYRIKOVICH. *Izvestiya Akademii Nauk SSSR* (Bulletin of the Academy of Sciences of the USSR), Section of Technical Sciences, 1950, p. 1137-1153, Aug.

Describes experimental investigation of the above at pressures up to 200 atmospheres and temperatures up to 600° C. Problems of circulation, heat exchange separation of water from steam and solubility of salts in high-pressure steam were studied in detail.—BLR.

7.6.4, 3.4.8, 3.5.9

Corrosion in CO₂-H₂S-Amine System. K. L. HUIJSACK, G. R. DAVIS AND E. C. CARLSON. *Stanolind Oil & Gas Co. Paper*, A.I.Ch.E. Reg. Meet., Kansas City, Mo. May 13-16, 1951. *Prog. Abstr.*: 26.

Rapid corrosion of tubes in the reboiler of an amine regenerator used in sweetening natural gas was found to occur when the amine contained small residual amounts of both carbon dioxide and hydrogen sulfide and the heat-medium oil was at 500° F. Reduction of the oil temperature to 370° F practically eliminated the corrosion in the pilot unit in which the study was carried out.

7.6.6, 8.5.3

Corrosion and Field Lining of Sulfate Digesters. T. T. COLLINS, S. J. BAISCH, AND G. T. VANDER VELDEN. *Thil-*

many Pulp & Paper Co. Paper Trade J., 132, No. 6, 24+ (1951) Feb. 9; No. 7, 18+ (1951) Feb. 16.

Problem of sulphate digester corrosion and procedures being undertaken by the authors to prolong the life of present digesters at the Thilmany Pulp & Paper Co. Suggestions that have appeared in the literature for preventing corrosion in digesters, for composition of the steels used for linings are listed. Various stainless steels and Monel, because of their failure in this application, were overlooked. An Inconel liner was installed in 1 digester. The installation procedure is described. 6 month observation of the liner showed apparent success of the project, and plans are being made for the installation of Inconel lining in all digesters. Illustration, a table giving data on Thilmany digesters (weight, cost corrosion, steel analysis, etc.) and 62 references are given.—INCO.

7.6.6, 8.5.3

First Published Kraft Industry Report: Digester Corrosion. FRANCIS W. FLYNN. *Pulp & Paper Ind.*, 25, 34-35 (1951) Jan.

Outlines experiences of various companies. Summarizes present knowledge of the above and discusses proposed cooperative research.—BLR.

7.6.8, 8.4.3, 4.3.4

New Flash Tower Resists High Sulfur Corrosion. L. W. WILLIAMS. *Lukens Steel Co. Petroleum Refiner*, 30, No. 1, 144 (1951) Jan.

To combat corrosive attack by sulfur, hydrochloric acid and organic chlorides,

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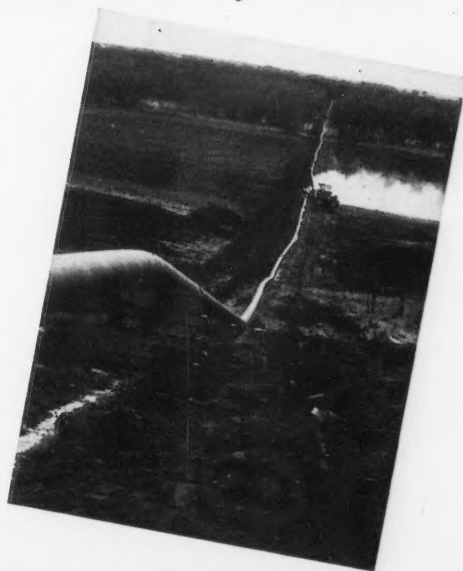
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the Socony-Vacuum Oil Co. plant at Paulsboro, N. J., has recently completed a 20,000 barrel per day combination atmospheric-vacuum unit. This unit was constructed of stainless-clad steel, Type 405. An asphalt-base crude containing as high as 2.50 sulfur, is topped in the atmospheric tower with a lube cut fed to a stainless-clad steel vacuum still where it is further processed at 750° F. The unit uses the largest clad steel head ever spun in one piece. A 20 foot, 4½ inch API-ASME Code flanged, dished and flued head, weighed approximately 20,000 pounds and had an over-all depth of 59-3/16 inches.—INCO.

7.7 Electrical, Telephone and Radio

7.7, 6.4.2

Aluminium-Sheathed Cables. *Metal Ind.* (London), 76, No. 19, 389 (1950) May 12.

Conventional lead cable sheathing is being replaced by aluminum. The British Insulated Callendar's Cables, Ltd. have several aluminum-sheathed cables on the market, the latest type being a 33 kv impregnated pressure cable manufactured in 330-yard lengths. The sheath of such a cable must withstand an internal nitrogen gas pressure of 200 psi. External steel reinforcement is required if lead is used, but is unnecessary with aluminum. The wall thickness of the aluminum sheath will not be less than 90 percent of the corresponding lead sheath. Corrosion tests on aluminum sheathing in both acid and alkaline soils have proved that the normal rubber bitumen sandwich serving offers adequate protection. Reinforcing tapes and the cast plumb are omitted with a resulting saving on cost and joining time. Improved techniques enable pressure of 1000 psi to be withstood for long periods without failure. The two methods of applying the aluminum sheath which are most developed are seamed aluminum tube (welded) and died-down sheath. The latter method has been adopted as the only practical means available for producing a seamless sheath. It consists of drawing the cable into an oversized tube; then both cable and tube are pulled through a "sinking" die which reduces the outside diameter to the required figure.—ALL.

7.7, 5.3.2, 3.5.1, 2.3.6

Filamentary Growths On Metal Surfaces—"Whiskers." K. G. COMPTON, A. MENDIZZA, AND S. M. ARNOLD. The Bell Telephone Laboratories, Murray Hill, New Jersey. Paper presented at the Seventh Annual Conference and Exhibition, Nat. Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 90, 327-334 (1951) Oct.

Filamentary growths have been found on metal surfaces of some of the parts used in telephone communications equipment, particularly on parts shielded from free circulation of air. The growths are of the same character as those known as "whiskers" and which developed between the leaves of cadmium plated variable air condensers, causing considerable trouble in military equipment during the early part of World War II.

An investigation has been under way in an attempt to determine the mechanism of growth of the whiskers, found not only on cadmium plated parts but also on other metals. This paper summarizes the findings to date as revealed by the study of approximately one thou-

sand test specimens of different metals, solid and plated, exposed under various environmental conditions. The study is being extended in the light of the findings which have developed during the course of the work.

While the whiskers normally are not found on parts such as condenser leaves for some time, often months, after being electroplated, it is possible, by increasing the ambient temperature, to so accelerate their growth that they will develop in a matter of weeks. So as to avoid the introduction of additional variables which so often attend accelerated methods of test, the greater part of the present work is being carried out at temperatures attained by equipment operating under normal exposure conditions.

The effects of humidity and the presence of various organic materials, different film thicknesses and methods of application, surface preparation and supplementary treatments, chemical and physical properties and X-ray studies of structure are discussed in the paper.

7.7, 5.7.4

Heat Pump Protects Underground Electric Cables Against Corrosion. *Heating, Piping, Air Conditioning*, 23, No. 2, 98-99 (1951) Feb.

Replacement of underground electric cables was an important item of maintenance expense after but a year of operation at the Chevrolet plant of General Motors in Southern California. Trouble was caused by the corrosion of the cable sheathing due to moisture condensed from outdoor air pulled into the relatively cool cableways. Steel power conduits fanned out from each manhole to a number of load centers. Problem was solved by a heat pump and an air circulating system to provide warm dry air in the cableways.—INCO.

7.7, 8.5.3

The Protection of Electric Equipment from Corrosion in Pulp and Paper Mills. G. W. KNAPP. General Electric Co. *Paper Trade J.*, 132, No. 3, 18+ (1951) Jan. 19.

Means of protecting electric equipment from corrosion. Steel surfaces of non-working parts receive special preparation (frequently phosphate treatment), then priming and finish painting using alkylid resin type paints. Working steel parts are plated, usually with zinc. Oil immersion may be used to protect static devices (transformers, capacitors). When corrosive conditions are bad, motors should be enclosed. Transformers, switchgear and motor-generator set should be installed in a protective room.—INCO.

7.8 Wires and Cables, Non-Electrical

7.8

Rope Failures in British Collieries. Paper before Conf. on Wire Ropes in Mines, Leamington Spa, England, Sept. 1950. *Mining J.*, 235, No. 6012, 441 (1950) Nov. 10.

Paper is devoted to failures in wire ropes in British colliery practice and deals with breakage investigations in the various types of colliery ropes over a period of 12 years. The breakages are analyzed from the point of view of predominant cause of failure, while cases of serious rope deterioration are similarly treated. The several forms of deteriora-

tion and faults in maintenance are discussed and remedies suggested. Corrosion, often progressing to corrosion fatigue, forms the greatest hazard to colliery wire ropes in Great Britain. To combat corrosion good zinc coatings should be used on the wires of the rope, combined with careful lubrication during manufacture and throughout service.—INCO.

7.8, 5.3.2, 5.4.5

Rustproofing Wirework. A. E. WILLIAMS. *Mech. World*, 128, No. 3320, 218-219 (1950) Sept. 1.

In reply to an inquirer asking about methods of rustproofing wire structures such that they exhibit a dark tone and, at the same time, will withstand heating in an oven for 1 hour at 350° C, the following suggestions are made: The use of alloy wires, coatings of bonded fiberglass, and zinc coatings applied either by hot dipping or Sherardizing. Sherardizing is unsuitable where soldered joints are involved since these would melt during the coating process.—ZDA.

7.8, 4.3.2, 6.2.5

Tensile Failure of Carbon and Stainless Steel Wires In The Presence of Water and Hydrogen Sulphide. J. E. TRUMAN. Brown-Firth Research Labs. *Metallurgia*, 43, No. 255, 8-10 (1951) Jan.

Premature failure of both ordinary and corrosion resisting steels, in conditions of service involving the presence of hydrogen sulfide, was investigated and tests carried out on a number of steels. Compositions of steel wires used were: carbon steel wire, 13 chromium steel wire, 18 chromium-8 nickel steel, 18 chromium-8 nickel-1 titanium and 18 chromium-8 nickel-2 molybdenum. It was shown that the combination of tap water and hydrogen sulfide at room temperature produced a considerable reduction in the life of steel specimens stressed to 40 percent of their maximum stress, although a chromium-nickel-molybdenum stainless steel showed no visible attack up to 10,800 hours. Investigation is described and tables are given.—INCO.

7.10 Other

7.10, 6.4.2

Aluminum Windows. *Ind. Finishing*, 3, No. 28, 255-257 (1950) Oct.

This article recommends that where aluminum is in contact with bronze, brass or gunmetal fittings, these should be zinc or cadmium plated to prevent electrolytic action; alternatively, a zinc chromate jointing compound may be used. Zinc chromate-pigmented paints are the most suitable primers for use on aluminum.—ZDA.

7.10, 8.1.2

The Care and Maintenance of Fittings and Equipment in the Modern House: Report of a Sub-Committee of the Central Housing Advisory Committee (Ministry of Health). Brochure, 1950, 57 pp. H.M.S.O. 1s, 6d.

Gives advice on installation and maintenance and describes the more common causes of failure. Pages 7-15 deal with aluminum and steel (carbon, stainless and galvanized) equipment, including possible causes of corrosion and its prevention. Other sections deal with solid fuel appliances, gas and electric equipment, floors, etc.—BNF.

7.10, 6.4.2

Gresford Cages—Progress Report. *Light Metals* (England), 13, No. 153, 522-523 (1950) Nov.-Dec.

The all-aluminum mine cages installed at Gresford Colliery in August 1949 were recently examined after 12 months' operation. Over 500,000 tons of coal have been hauled in them. No trouble has been experienced from the day of installation, and appreciably less power is required from the winding engine because of the light weight. The paint work is sound and shows no signs of deterioration, either on the plain surfaces or around the rivet heads. The paint treatment included the application of etch primer, a coat of red oxide and a finishing coat of leafing aluminum paint. Occasional cleaning during the course of routine maintenance removed deposits of grime. There were no signs of corrosive attack, even on the underside of the deck. Junctions between steel gusset plates and aluminum members, and steel rivet heads in aluminum members, were carefully cleaned for close examination. The paint was intact and there were no signs of galvanic corrosion between the dissimilar metals. Plates and sections were in good condition and all riveting was sound. The rails and deck plates made of high-strength aluminum alloy gave very good resistance to wear. It was concluded that both the design and construction have been fully justified in service.—ALL.

7.10, 6.3.6

Reports on Miscellaneous Metallurgical Investigations. H. H. SYMONDS. *J. Birmingham Met. Soc.*, 30, 92-116 (1950) Sept.

Presents results of investigation of the following cases: Failure of Brass Nuts From the Filling Heads of an Aerated Water Machine, Investigation Into the Premature Failure of Welt Needles, Cracking of Lipstick Holder Caps and Surface Imperfections on Brass Trays. Includes numerous photomicrographs.—BLR.

7.10, 6.4.2

A Light Alloy Dragline Bucket Has Lasted Longer Than Four Equivalent Steel Buckets (Une benne de dragline en alliage léger a tenu pendant plus longtemps que quatre bennes en acier). *Revue aluminium* (France), 27, No. 163, 48-49 (1950) Feb.

A light alloy dragline bucket constructed by Head, Wrightson Light Alloy Structures Ltd. from aluminum supplied by the Reynolds Rolling Mills has been used for work on the London airport at Heath Row. The bucket has a capacity of 17.7 cu. ft. and remained in service for 14 months to shift nearly 3.5 million cu. ft. of sand before needing repairs. It would have completely worn out four equivalent steel buckets to do the same work. British technicians attribute the wearing qualities of aluminum in this application to three reasons: 1) the greater aptitude of aluminum to absorb mechanical wear due to impact, characterized by its relatively low modulus of elasticity; 2) the very light superficial hardness of aluminum permits fine particles of sand to adhere, thus improving the wear resistance; 3) the combined actions of oxidation and abrasion limit the use of steel buckets—rust, which forms very quickly on the surface of rapidly scraped steel will be removed rapidly by the operation of the following charge; with light alloy, a comparable

consumption of metal is not produced and the effects of abrasion are consequently less harmful. The article is well illustrated.—ALL.

8. INDUSTRIES

8.3 Group 3

8.3.5, 7.10, 4.4.2

Protective Films for Pilot-Plant Deodorizers. R. E. BEAL AND E. B. LANCASTER. Northern Regional Research Lab. Paper before Am. Oil Chem. Soc., Atlanta, May 1-3, 1950. *J. Am. Oil Chem. Soc.*, 28, No. 1, 12-16 (1951) Jan.

Laboratory tests show that the problem of contamination of soybean oil by metals during deodorization is one of simple fatty acid corrosion. Polishing the surface of mild steel or stainless steel greatly reduces corrosion of the metal while depositing certain protective films. making the surface nearly equal to a glass surface so far as the effect of the oxidative and flavor stability of soybean oil is concerned. The experimental methods and results are discussed. Results of work with cottonseed oil have led to the increased use of aluminum and nickel in the construction of deodorizers. Nickel, though successful in this application is relatively expensive. Mild steel has desirable structural properties and is not as expensive, but it affects oil stability adversely; certain types of stainless steel are better in this respect but are more expensive. Alloys tested include nickel, 304, 316, 321, 347 stainless and mild steel, Croloy Type 2, Inconel and Hastelloy B. Tables of results and 7 references are given.—INCO.

8.3.3, 6.6.6

Glass Lines: Do A-1 Job; No "Take Down" to Clean. F. F. FLEISCHMAN, J. C. WHITE AND R. F. HOLLAND. Cornell Univ. *Food Inds.*, 22, No. 10, 47-51, 182, 184 (1950) Oct.

The article outlines the advantages of glass over stainless steel pipe for use in the dairy industry. The surface of stainless steel is rough and grooved while glass has a smooth surface. The glass pipe does not have to be dismantled for cleaning. Pipe installation is discussed. Three types of stainless steel adaptors are used to clamp glass pipe to hangers. Bacteria count methods are described and a table of results is given. Passage of milk through glass pipe did not have any effect on the bacterial count and no positive coliform tests were obtained from any sample.—INCO.

8.3.3, 7.4.2

Corrosion of Plate Apparatus for Milk Pasteurization. S. BRENNERT AND W. TEICHERT. *Svenska Mejeritidn.*, 41, 495-498+ (1949).

Study of corrosion occurring in stainless steel heat exchangers by cleaning fluids used, nitric acid and sodium hydroxide. Results indicate that corrosion is caused by galvanic action. Results of experiments are summarized.—INCO.

8.3.5

Where Corrosion Is Most Severe. *Die Castings*, 8, No. 11, 22-23+ (1950) Nov.

Designed to operate under conditions of extreme heat and cold, and exposed to grease, oil, animal fats, blood and salt brine, hand truck wheels for the meat packing industry have die cast aluminum hubs and zinc hubcaps.—INCO.

8.4 Group 4

8.4.3, 5.4.8

Protective Coatings Against the Sea. *Can. Paint & Var. Mag.*, 24, No. 11, 24, 26 (1950).

Steel platforms built into the sea bed of the west Gulf of Mexico from which oil-drilling operations are carried out, are protected against corrosion with a diversity of paint systems. Underwater, cathodic protection of the zinc chrome primed steel piles is used. Between high- and low-level water marks, protection is by a system of felt wrapping and fiberglass wrapping painted over with coal tar enamels. From high-level mark to the working platform, a zinc chrome primer and black phenolic finish are first applied, followed by a non-drying composition of zinc dust and zinc oxide in petrolatum, trowelled on. On the superstructure, conventional paints based on alkyds are used.—RPI.

8.4.3, 4.3.2, 4.3.3, 3.5.9

The Selection of Ferrous Metals for the Oil Refining and Petro-Chemical Industry. W. P. KERKHOFF, H. G. GEERLINGS AND H. VAN DER HAAS. Paper before Soc. Chem. Ind., Birmingham, Apr. 18-20, 1950. *Materials of Construction in the Chemical Industry*, 1950, 125-135; Disc. 135-138.

A description is given of the nature of a number of factors which play an important role in petroleum industry metal selection. The corrosion resistance against different chemicals such as hydrogen sulfide, or hydrochloric acid is taken into account and the welding features are discussed in detail. In an analysis of strength and ductility at normal and higher temperatures, the establishment of a more correct evaluation of allowable stress is attempted with the aid of rupture theories based on modern conceptions. Discussion of high temperature corrosion and assembly aspects covers corrosion by sulfur and sulfur compounds and vanadium ash. Physical aspects of materials selection covers strength and ductility at temperatures above and below 350° C. Applications of stainless steels are mentioned throughout.—INCO.

8.4.3

How Atlantic Refining Co.'s Oil-Producing Department Functions in Planning Corrosion Studies. J. A. KORNFELD. *Oil Gas J.*, 49, No. 42, 189+ (1952) Feb. 22.

Procedure for handling a corrosion study in the engineering department of the Atlantic Refining Co. at Dallas. Responsibility is focused directly on certain groups, progress reports are made and each project is carried to logical conclusions. This comprehensive control tends to bring about a maximum return on the research dollars.—INCO.

8.4.3, 6.5

Welding Quality Control in a Petroleum Refinery. A. F. BLUMER, Esso Standard Oil Co. Paper before ASME, Petrol Div. Conf., New Orleans, Sept. 1950. *Petroleum Refiner*, 29, No. 11, 101-108 (1950) Nov.

Description of the welding operations in a Baton Rouge refinery. Pipe, plate and structural and alloy welding and welding storage vessels are discussed. Welder's qualification tests, welding inspection and procedure, evaluation of welding electrodes and welding research are given. Corrosion and service condi-

tions have led to the use of high carbon and carbon-molybdenum steels, 5,9, and 13 chromium alloys, 18-8, 25-12, and 25-20 chromium-nickel alloys, Durimet, Worthite, Hastelloy B and D, Monel, commercial nickel, 1 and 3½ nickel steel, Cyclops, brass alloys, copper, aluminum, Inconel, lead, Colmonoy, Stoodite and Stellite. Clad materials where steel sheets are surfaced in Monel, nickel and 18-8 chromium-nickel are also used. In the handling of chemicals a large amount of copper or copper alloy is used. Illustrations are given.—INCO.

8.5 Group 5

8.5.3, 6.3.10, 6.2.5

Construction Materials in the Paper Industry. Parts I-IV. *Chemical Engineering*, 57, 211-212, 255-256, 223-224 (1950), Sept., Nov., Dec. ibid 58, 217-218 (1951) Jan.

I. Consists of separate articles as follows: "Lead," Kempton H. Roll; "Monel, Nickel, Inconel and Ni-Resist," H. O. Teeple; "Worthite," W. E. Pratt; "Cements," Raymond B. Seymour; "Iron and Steel," Arthur E. May and Albert W. Spitz;

II. Consists of the following sections: "Chlorimet," Walter A. Luce; "Durimet 20," Walter A. Luce; "Tantalum," Leonard R. Scribner; "Iron and Steel," Arthur E. May and Albert W. Spitz; "Worthite," W. E. Pratt; "Coatings," Kenneth Tator; "Lead," Kempton H. Roll; "Rubber," James P. McNamee;

III. Consists of the following brief articles: "Worthite," by W. E. Pratt; "Lead," by Kempton H. Roll; "Cements," by Raymond B. Seymour; "Rubber," by James P. McNamee; "Iron and Steel," by Albert W. Spitz and Arthur E. May; "High-Silicon Irons," by Walter A. Luce; "Nickel, Nickel Alloys," by H. O. Teeple; "Chlorimets," by Walter A. Luce; "Stoneware," by M. J. Winston; and "Durimet 20," by Walter A. Luce;

IV. Consists of following short articles on the applicability and corrosion resistance of specific materials for process equipment used in alkaline pulping: "Worthite," W. E. Pratt; "Carbon," L. C. Werking; "Cements," Raymond B. Seymour; "Durimet 20," Walter A. Luce; "High-Silicon Irons," Walter A. Luce; "Chlorimets," Walter A. Luce; "Iron and Steel," Arthur E. May and Albert W. Spitz; "Rubber," James P. McNamee; "Nickel, Nickel Alloys," H. O. Teeple.

8.7 Group 7

8.7.1, 5.9.4

Lithographic Plate Surface Treatments: Cronak for Zinc, Brunak for Aluminum. M. H. BRUNO AND P. J. HARTSUCH. Lithographic Tech. Foundation, Inc., Instructions for Use No. 802, 1950, 29 pp. May be purchased from the Foundation, 131 East 39th Street, New York 16, N. Y., U.S.A.

In view of the acute corrosion difficulties experienced with lithographic plates in tropical conditions during the war, protective methods of treatment were developed which are now generally used. The well-known Cronak treatment for zinc (sodium bichromate plus sulphuric acid) has been suitably modified for lithographic plates; and the Brunak treatment (hydrofluoric acid plus ammonium

bichromate) has been developed for aluminum plates. In the present publication the subject is developed purely from the point of view of the lithographer.—BNF.

8.8 Group 8

8.8.1, 4.4.1

Amyl Compounds from Pentane. R. L. KENYON AND G. C. INSKEEP. In collaboration with L. Gillette and J. F. Price. *Sharples Chem. Ind. and Eng. Chem.*, 42, No. 12, 2388-2401 (1950) Dec.

Tables of materials of construction lists Monel-clad cone pentane dehydrator, copper kettle and column during esterification operation, stainless steel condenser and subsequent lines carrying tert-amylphenol, nickel-clad autoclave containing secamylphenol and Inconel-clad autoclave containing amyl mercaptan. Steel is used practically everywhere else.—INCO.

8.8.1, 4.3.6

How Morton Salt Refines Salt, Fights Corrosion and handles Solids. J. A. LEE. *Chem. Eng.*, 58, No. 1, 102-105 (1951) Jan.

Among the 3 things that impress most chemical engineers is the different materials of construction that are used to fight corrosion of processing equipment and to prevent contamination of high-purity products. Monel and Type 316 stainless steel are used interchangeably for many purposes. However, Monel pipe lines and 4-in. rubber hose are more effective in handling hot brines and hot slurries. Stainless steel is largely used to prevent corrosion and contamination. Ni-Resist is used for hot brine pumps. Slurry pumps have rubber stators. Most bolts and nuts are stainless steel. All screw conveyors are covered with a protective coating of phenolic resin. Some neoprene coating is also used in the plant. Silos are constructed of glazed tile. Hardwoods are used for salt storage bins in the mill building.—INCO.

8.9 Group 9

8.9.1, 5.4.5

Aircraft Finishing Techniques Stress Utility. G. C. Close. *Products Finishing*, 14, No. 9, 56-60 (1950) June.

The highlights of Northrop Aircraft methods of finishing aluminum, magnesium, steel and glass cloth laminated components in aircraft to prevent corrosion are described. Aluminum sheet is primed with a modified zinc chromate primer conforming to Specification AN-P-656 on arrival. "Kotal," a vinyl chloride transparent strippable plastic film conforming to Specification AN-C-145 is sprayed on aluminum and magnesium sheet as protection against corrosion and abrasion during construction of the aircraft. Fabricated aluminum parts are cleaned in a mild alkaline cleaner and then anodized in chromic acid to produce an oxide coating about 0.00005 in. thick. Fabricated magnesium parts are degreased in a trichlorethylene degreaser, pretreated in a 10 percent nitric acid and 10-20 percent sulfuric acid bath, finished with Dow No. 7 acid dichromate treatment, given two coats of modified zinc chromate primer and one coat of grey enamel conforming to Specification AN-E-7. Magnesium components too large to immerse in surface treating tanks are

flushed with a 3 to 5 percent solution of hydrofluoric acid. Precautions must be observed to prevent corrosion between dissimilar metals. Zinc Chromate paste is used where dissimilar metals are joined, 56S rivets are used with magnesium and steel bolts are cadmium plated and then given a zinc chromate coating. Whether the exterior is left unpainted as for most commercial aircraft, or covered with a camouflage coating for combat planes, the surface must be free from any irregularities. Minor blemishes are filled in with coats of Rex-118 primer-surfacer while major dents are filled first with PX 4045 airfoil putty.—ALL.

8.9.1, 5.1

Causes of Corrosion in Airplanes and Methods of Prevention. N. H. SIMPSON. Consolidated Vultee Aircraft Corp., Fort Worth Division, Fort Worth, Texas. Paper, South Central Regional Meeting, Nat'l. Assoc. Corrosion Engrs., Oct. 3-4, 1949, Dallas, Texas. *Corrosion*, 6, No. 2, 51-57 (1950) Feb.

The author endeavors to point out the varied types of corrosion which may occur on present types of aircraft and the latest methods of combating them. He also stresses the importance of continuous research into the corrosion problems of supersonic aircraft and missiles. At the same time some of the possible reactions that may occur at high speeds between the atmosphere and the aircraft or missiles' exposed surfaces are brought out.

8.9.2, 6.1

Corrosion Problems Related to Air Transport Aircraft. O. E. KIRCHNER AND F. M. MORRIS. Paper, 6th Ann. Conf. Nat'l. Assoc. Corrosion Engrs., St. Louis, Mo., April 4-7, 1950. *Corrosion*, 7, No. 3, 161-177 (1951) May.

Individual part protection is being adopted on aircraft superseding older methods of final overhaul in which coatings were applied after assembly and installation.

Special attention is given to aluminum alloy structure design to eliminate moisture collecting depressions and areas.

Electrical battery installations pose special problems. Control cables passing through pressure bulkheads wear off corrosion protection. Effect of exhaust gases on structure is well understood. Food buffets are a major problem because of food and liquid spillage. Protection from lavatory and wash water corrosion is not completely satisfactory.

Magnesium in power plants causes problems and undrained low spots corrode. Dissimilar metals in engines must be studied for corrosive effects. Radiators, feed valves, ignition systems and injectors need watching on this score.

The trend to steel propellers requires added steps in overhaul to protect abraded leading edges. Moisture under deicer boots must be watched. Improper heat treatment results in intergranular corrosion.

Varied sources of water used on aircraft necessitates careful placement of ground station filters, softeners, demineralizers or stills.

8.9.2, 4.1

Corrosion Problems of Motor Coaches. K. L. RAYMOND. Paper, 7th Ann. Conf. Nat'l. Assoc. Corrosion Engrs., New York, N. Y., March 13-16, 1951. *Corrosion*, 7, No. 9, 303-307 (1951) Sept.

Motor coaches must provide safe and dependable transportation. Quite a variety of corrosion problems present them-

selves in the construction and operation of motor coaches. Some of those which concern the body are: electrolytic or galvanic corrosion between the aluminum and steel of body and frame; water vapor condensation due to respiration by passengers; abrasion and corrosion of understructure by stones and other debris thrown up by the tires, including chlorides used on the roads for de-icing and dust control; acid attack by battery electrolyte; wear and attack on stan- chions, grab rails and other assist handles due to perspiration, rough hands and fabrics. Coach engines have their share of corrosion problems, too, particularly in the cooling and exhaust systems. Although numerous corrosion inhibitors do a reasonably fair job in the cooling system. Exhaust systems suffer from cold corrosion due to acid from condensation of products of combustion of the engine. However, high temperature oxidation is usually a more serious problem than cold or acid corrosion in motor coach engine exhaust systems. On some heavy duty operations the exhaust pipe runs as high as 1600° F for many hours at a time.

8.9.3, 5.10

Rock Shields Prove Economical in Protecting Pipe-Line Coating. P. REED. *Oil Gas J.*, 48, No. 11, 84+ (1949) July 21.

Rock damage to the coating of a 286-mile 26-inch natural gas pipe line being laid from Glendennin, W. Va. to Rockville, Md. is prevented by wrapping the pipe with pliable hard mastic board shields made by Keystone Asphalt Products Co. The shields are bound to the pipe with a special wood-fiber strapping material. Total installed cost of the shields is \$0.35 per running foot, several times less than dirt padding would cost in the W. Va. mountains. The shields will be tried for wrapping coated pipe at river crossings, for padding pipe against river clamps and hold down anchors and for protecting pipe sections pulled across swamps and through casing at road crossings. It is estimated that there is a potential use for the method in 10 percent of pipeline construction.

8.9.3, 7.2, 5.8.2, 5.2.2

Internal and External Corrosion Experience in Shell's Products Pipe Lines. S. S. SMITH, W. J. CURRY AND E. H. RUSH. *Corrosion*, 7, No. 1, 20-28 (1951) Jan.

The first section of this paper summarizes ten years of experience on two product lines operated by Shell Oil Company using alkaline aqueous solution of sodium nitrite as an internal corrosion inhibitor. The second section discusses the use of magnesium anodes as an external corrosion preventive on Shell's products pipe line from Wood River to Chicago. The line is now 26 years old and was 21 years old with a moderately high leak frequency when anode installations were instituted. In order to analyze the effects of anode installations, pilot plant experiments were conducted, and the paper reports these pilot plant experiments and their results and the conclusions drawn therefrom. Included in this section of the paper are several sets of field tests conducted before anodes were installed, after anodes were installed and over several years of life of anodes. Picture and drawings support the conclusions drawn from pilot plant experiments and results of field tests and experience during the five

years of experimental work on the line are summarized. The conclusions drawn from this section of the report are that proper field testing and installation of magnesium anodes can control destructive corrosion sufficiently to extend the useful life of uncoated pipe lines to approximately double their unprotected life.—ALL.

8.9.3

Resumé on Modern Practice in Prevention of Corrosion of Buried and Submerged Structures. K. A. SPENCER. Anglo-Iranian Oil Co. Engineering Report No. 40, Oct. 24, 1949, 17 pp. Issued by the Company, Britannic House, Finsbury Circus, E.C.2.

Discusses briefly several theoretical causes of corrosion and gives practical instances showing how each of these may operate when structures are buried in the soil. Protective measures are described, particularly coatings for pipes and cathodic protection.—BNF.

8.9.4, 6.4.2

An Aluminum Alloy in Car Construction. E. C. HARTMANN, G. B. HAUSER, AND R. L. MOORE. *Ry Mech. Elec. Engr.*, 124, 717-721 (1950) Dec.

Describes superior mechanical and corrosion-resistant properties of 61S-T6, and its use for freight- and passenger-car construction. Test results are charted and illustrated.—BLR.

8.9.4, 5.4.5

Motor-Car "Measles." Paint Manuf., 20, No. 11, 385 (1950).

Widespread appearance of paint blisters on motor-cars following hurricanes is ascribed to the low pressure centers of these storms expanding air bubbles beneath the paint film, followed by moisture seeping in, thus further swelling the blisters. No way of preventing the effect has been found.—PRI.

8.9.5

Naval Engineering Duty in Peacetime (Protection of Ships). RICHARD DOUGHTON, JR. *Metal Progress*, 56, No. 6, 829-832 (1949).

A general description is given of some methods adopted in the U. S. Navy to prevent deterioration by corrosion of ships held in reserve.—MA.

8.9.5, 6.4.2

Shipbuilding and Marine Engineering in 1950—Light Alloys for Shipbuilding. *The Engineer* (England), 191, No. 4955, 52-53 (1951) Jan. 12.

Aluminum alloys were widely used for small craft and for non-stressed ships' structures during 1950. Investigations were carried out on riveting and welding techniques. Argon arc welding has proved to be promising and the Cyc-Arc Company developed a technique for welding non-heat-treatable aluminum alloy studs to plate of similar material. Investigations into the problem of differential expansion showed that longitudinal compressive stresses induced under certain conditions are great and transverse stresses are considerable. Several ships including the "Blenheim" and "Lady Wright" were fitted with aluminum wheelhouses, navigating bridges and funnels, and aluminum continued to be used for insulation lining. The use of aluminum expanded in the fishing industry where its non-toxic and corrosion-resisting properties made it suitable for fish room applications. Many small craft were constructed.—ALL.

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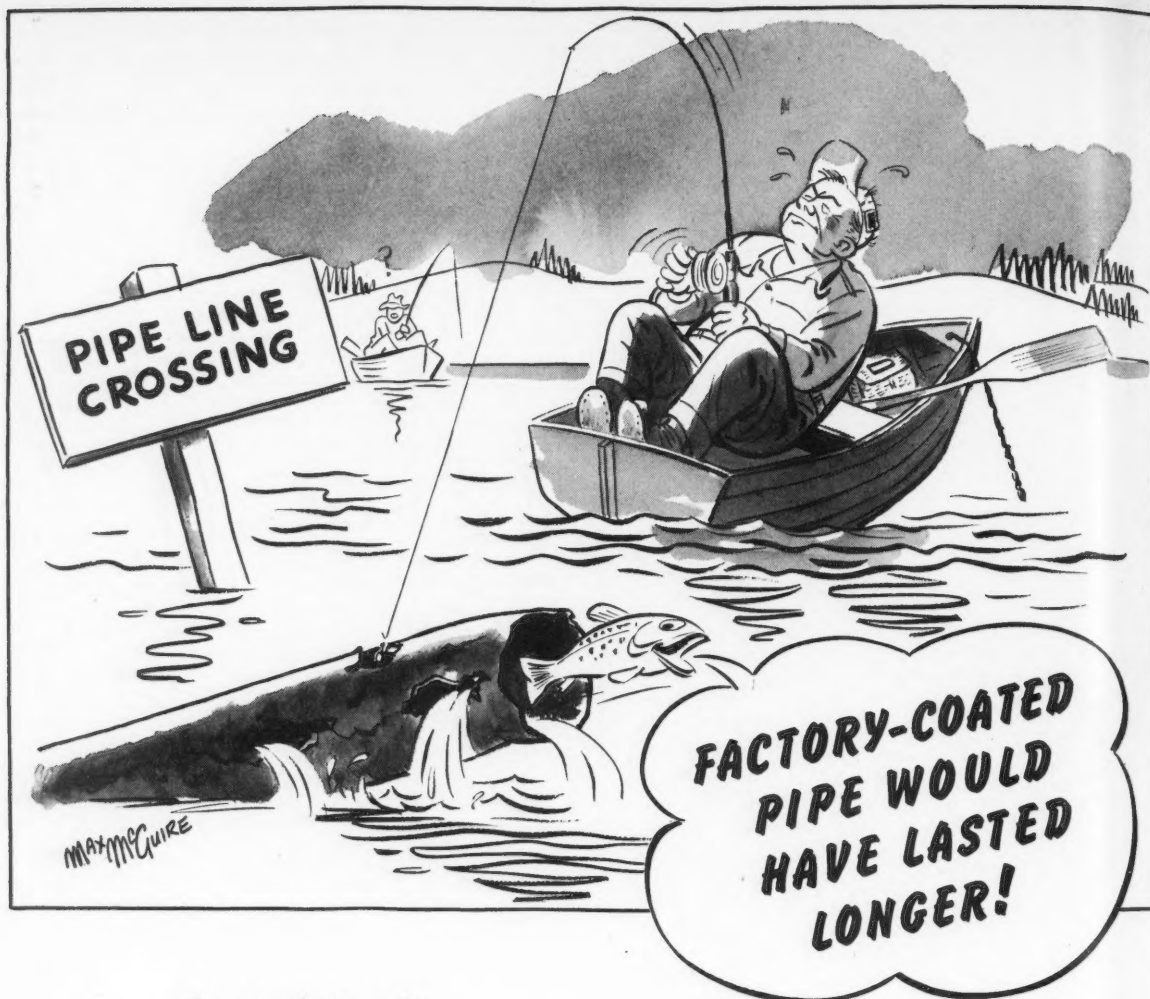
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8.9.5, 3.5.8

Presidential Address. S. F. DOREY. *Inst. Mechs. Engrs.*, 162, No. 3, 368-377 (1950).

Describes experiences in the fields of boilers and pressure vessels (design, materials selection, caustic cracking, corrosion and welding); Marine-engine shafting (elastic hysteresis, corrosion fatigue, torsional vibration, and other causes of service failures); marine-reduction gearing (design and machining); hull vibration and engine balance and strain measurement.—BLR.



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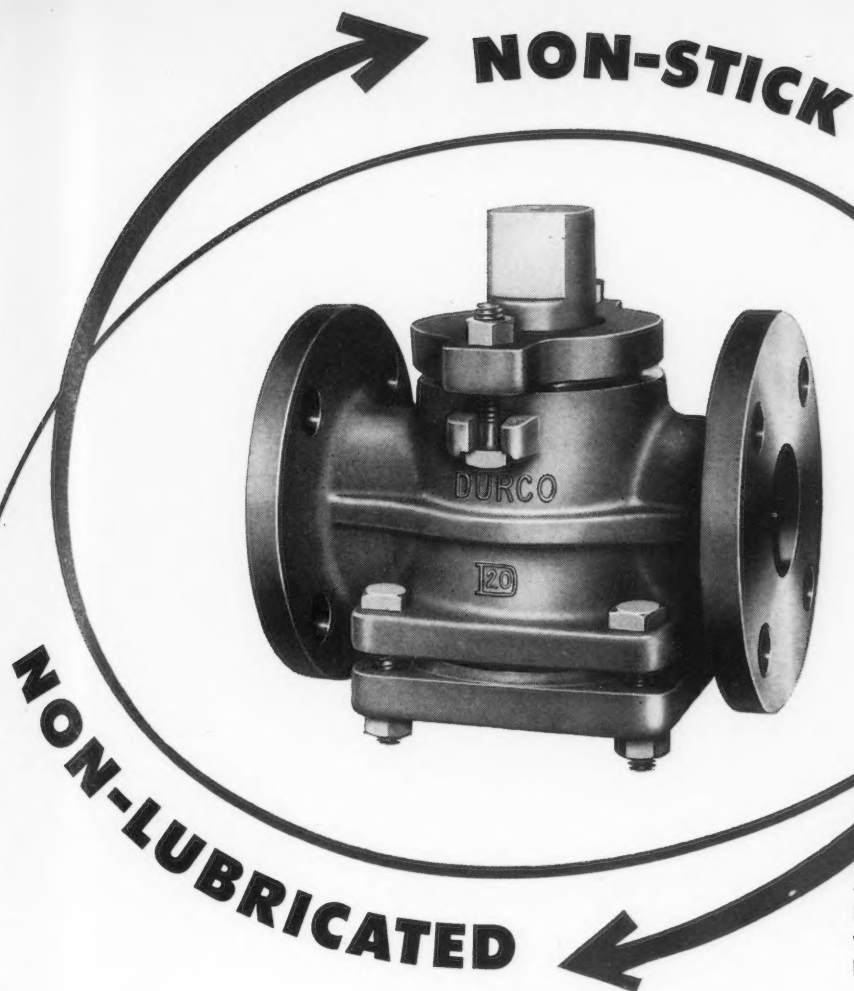
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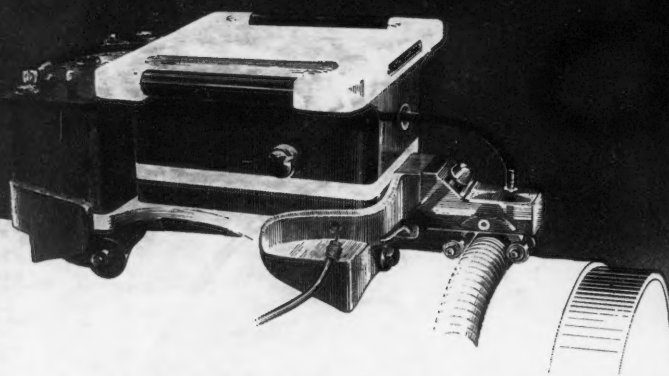
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The STEARNS ELECTRONIC HOLIDAY DETECTOR



The STEARNS ELECTRONIC HOLIDAY DETECTOR* is a device

for making high voltage electrical inspection of pipe line coatings, above ground, as the unit is rolled along on the coated pipe by an operator. The complete Unit consists of the Generator coupled with an Alarm System, the Rolling Coiled Spring Exploring Electrode and Pusher Carriage Assembly. A small 6-volt storage battery serves as the power source.

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Fundamental precepts which are met by the Stearns Detector are:

(1) To generate a high voltage pulse of short duration regulated to hold the crest intensity within narrow limits irrespective of pipe size and the variable moisture conditions experienced during field inspection;

(2) To cause such a pulse to re-occur at a rate rapidly enough so as to have entirely traversed the coating surface with successive overlapping circumferential bands of ionization as the testing electrode is moved along the coated pipe;

(3) To apply, in a simple manner, these testing pulses to the coating by means of an exploring electrode embracing and self-conforming to the variable shape of the exterior of the coated pipe while being held in electrically effective contact with the coating surface at all times; and

(4) To give out audible and visual alarm signals as an instantaneous response actuated by the formation of a spark between electrode and pipe upon encountering a fault in the coating.

Under these principles the Stearns Detector in operation approaches the ideal in testing technique, with maximum safety to the operator, by providing thorough one-pass coverage while uniformly subjecting the coating only to the extent of electrical stress necessary to ensure complete inspection.

LIGHT WEIGHT

The Stearns Detector is fabricated from the lightest materials available having the required mechanical and electrical strength. The complete unit weighs 28 pounds, is 13.5" long, 9" wide, 7.5" high. A welded magnetic case for the Detector, and a wooden box for two 10 6-volt batteries serve as sturdy containers for storage and shipping. The complete shipping weight, including overnight battery charger, is 75 pounds.

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The Stearns Detector can be operated without special training or experience on pipes of all sizes. The proper voltage is set before shipment and the regulation is automatic—all functions of the Detector being controlled by a single 'On'-'Off' switch. The patented generator, which makes possible such automatic regulation, is an exclusive feature of the Stearns Detector.

DEPENDABLE SERVICE

The Stearns Detector has been developed through years of field experience and continued research and has become the Standard of the Industry. All major parts and the high voltage generating circuit are custom built to their specific functions and fitted together to form an electrical assembly of proved dependability.

Users of Stearns Detectors are constantly assured of receiving equipment in new condition as a result of the rigid shop and laboratory maintenance procedures followed by The E. Stearns Company.

*Patent Numbers Furnished Upon Request



The **D.E. STEARNS** Company

SHREVEPORT, LOUISIANA, U. S. A.

CABLE ADDRESS: DESCO

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